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LITERATURE FOR 1910 ON THE BEHAVIOR OF LOWER INVERTEBRATES

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The paper by Andrews[26] on Conjugation in the Crayfish consists of a detailed description of the method of conjugation. There is no evidence that sight or smell is an important element in this process. "Sex 'recognition' exists, apparently, only in the sense that the male may carry out all the stages of conjugation if a female happens to be seized, but not if a male is seized. There is no evidence that the male recognizes the female as such, or as a whole. But the passive response of the female when seized makes the completion of conjugation possible when the more effective resistance of the male when seized sooner breaks the series of conjugation acts."

In Banta's paper[27] comparisons were instituted between the reactions of the surface form, *Asellus communis*, and a related cave species, *Cecidotaea stygia*. The former shows no response to light of 1CM or less, but becomes restless when exposed to strong light. It is apparently negatively phototactic to strong horizontal rays, but it is photokinetic at the same time, most of the reactions showing a combination of the two modes of response. When subjected to vertical illumination Asellus becomes restless and tends to come to rest in a shaded area. Cecidotaea is markedly photokinetic in strong light, but it is not so sensitive as Asellus. In both species the reactions to light become less vigorous after a considerable exposure. Darkness renders them more responsive after they are brought into the light again, and Asellus may become positive for a short time after it is taken from the dark. While Asellus is the more sensitive to light, Cecidotaea reacts more readily to mechanical stimuli and to currents of water, and is more discriminative in food taking. The differences in the behavior of the two species are considered to be largely responsible for their differences in habitat.

Carpenter [33] has shown that when meat or solid food is placed on the disk of the rose coral the disk is drawn down, and the margin of the oral surface folded over, thus improvising a sort of digestive cavity. At the same time the stomodeum is everted and the mesenterial filaments extruded through the mouth, and digestion takes place in the space formed by this invagination. The cilia of the tentacles beat outward as in many other anemones and serve to rid the disk of foreign bodies, but occasionally in response to food stimuli the direction of the ciliary beat is reversed. There is a transmission of impulses from the ectoderm through the mesogloea to the entodermic muscles, but the histological basis for this transmission is at present not satisfactorily determined.

The object of Cowles's [34] study was to determine whether it is the direction of the rays or the relative intensity of the light that controls the direction of movement in the starfish. Light was admitted through a prism of India ink, in such a way that it gave a field of graded intensity in the aquarium below, in which the starfish were confined. It was shown that the starfish uniformly moved from the darker to the lighter end of the aquarium, regardless of whether they moved with or against the direction of the rays. A specimen with the tips of the rays amputated reacted in the same way, but much more sluggishly.

Cowles [35] gives a general account of the normal behavior of several species of ophiurans. Normal locomotion, the rôle of the tube feet in locomotion and feeding, and the righting movements are described in detail. The direction of righting is influenced by light, contact, and the previous handling of certain rays. The ophiurans react negatively to light and show a tendency to approach dark walls.

While the greater part of Dakin's [36] paper deals with the structure and connections of the visceral ganglion, there are included a number of interesting observations on behavior. Pecten is capable of rapid swimming by the alternate opening and closing of the valves of the shell. It may be induced to swim by various kinds of stimuli, but it is particularly sensitive to the presence of a starfish. It does not recognize the starfish by sight, since if some of the pulp of a starfish is introduced near a Pecten with a pipette the same precipitate flight is made. Destruction of the abdominal sense organ or the osphradium does not prevent this response. Pecten normally lies on its right side, and if placed on its left side quickly rights itself. Orientation is believed to be controlled by the otocyst, but this was not conclusively proven.

Most of the observations of Doflein [39] were made on two species of Leander, although some other decapods were studied. There are many observations and experiments on color changes and reactions to variously colored environments. Studies were made of reactions to touch, chemicals, and light; of the habits of the animals, and the characteristic responses of various parts of the body.

Various species of Cladocera were found by Ewald [40] to undergo periodic changes of light reactions of only a few minutes duration. Cladocera adapt themselves rather quickly to light of a certain intensity, and after a number of periodic migrations gradually cease to respond. A diminution of light tends to make them positive, while an increase of light induces the negative reaction. All the reactions of the Cladocera to light are attributed to variations in the intensity of light. The daily depth migrations of Cladocera are explained as due, in large part, to changes in the sense of phototaxis consequent upon the increase or decrease of light. There is a lengthy discussion of the general subject of orientation. The distinction commonly made between phototaxis and photometry or photopathy is not a valid one, since all reactions to light are considered as reactions either to an increase or a decrease of illumination. There is no evidence, according to the author, that light acts as a constant stimulus. Phototaxis occurs where the reaction to the stimulus happens to be an orienting one. Positive or negative reactions depend upon whether the animal is more stimulated by a decrease or by an increase in the intensity of light.

Franz [42] claims that phototaxis in many cases is a laboratory product, being often the result of confinement within a small space. The positive reaction is observed commonly in forms which often find a means of escape by going towards large lighted areas. Reaction to light in most higher forms is adaptive.

Both papers by Hachet-Souplet [8,9] deal with the practical methods employed in the formation of associations in the animal mind.

Hargitt [43] describes the explosive discharge in rapid succession of the sex products of a number of specimens kept in an aquarium. It remains a question whether the sex products matured so nearly at the same time that they were all discharged within thirty or forty minutes, or whether the discharge of one individual afforded a stimulus which evoked the discharge in the others. Similar observations are cited in other species.

Herbst [44] shows that the heteromorphic antennule which is regenerated in the place of an eye in Palinurus and Palaemon reacts to mechanical and chemical stimuli in a manner quite different from the response of the normal antennule. In many respects the reactions are like those elicited by the stimulation of the optic peduncle, the differences being perhaps due to the difference in structure and musculature of the two organs. The experiment is of especial interest in relation to the doctrine of the specific energies of the nervous system.

Hess's paper [45] contains numerous observations on special features of the light reactions of both vertebrates and invertebrates. It is mainly devoted to a consideration of the effects of light of different wave-lengths on the movements of animals. Experiments were carried out upon several species of caterpillars, Daphnia, Podopsis, and Atylus among crustacea, Culex, Musca, Coccinella, and other insects; Sepia, Eledone, and several eyeless bivalves among the mollusks, and Amphioxus. The general conclusion reached is that all these forms are most affected by the green or yellowish green rays. Judging from their behavior, the curve of brightness of the spectrum is the same for these animals as for color-blind human beings.

Specimens of *Eubranchipus ornatus* sp. nov. were found by Holmes [46] to be strongly positive to light from a narrow source such as an incandescent light in a dark room, although they manifested no marked reaction to diffused light coming through a window. If illuminated from below, Eubranchipus swims ventral side downward, instead of in its usual position on its back. Two different methods of orientation are employed, according to the degree of angular deviation from a direct course towards the light.

Besides giving a general account of the reactions of the crayfish to olfactory stimuli, the paper by Holmes and Homuth [47] contains a record of experiments on the effect of the removal of the antennae and antennules and the destruction of the brain. Removal of the outer ramus of the antennules, which bears the so-called olfactory clubs, was followed by a much greater loss of sensitiveness to olfactory stimuli than was produced by the removal of the inner ramus or the large antennae. Specimens with the inner ramus removed react less promptly than normal animals. In specimens with the brain destroyed, the small chelipeds and mouth parts showed a response to meat juice by the usual feeding movements. Various parts of the body were found sensitive to olfactory stimuli, but the region of greatest sensitiveness is the outer ramus of the antennules.

A study has been made by Hurwitz [48] of the reactions of earthworms to equimolecular solutions of various acids, and the conclusion was reached that the reactions are due to the hydrogen ions. While in general the reaction times were found to be proportional to the number of hydrogen ions in the solution, acetic acid was shown to have a greater stimulating power than its degree of dissociation would lead one to expect.

Jackson [49] finds that Hyalellas, which are ordinarily negatively phototactic, may be rendered positive by various chemicals. Acids, alkalis, and various other chemicals were employed, and it was found that there was apparently no relation between the class of chemical employed and the change of response. In order to test the suggestion that the change might be caused by chemical changes produced in the tissues, rather than by the direct stimulating effect of the chemicals used, the experiment was tried of very slowly increasing the amount of chemical in the water in which the animals were placed. It was found that it required a considerably stronger solution to cause the change of response than was necessary if the Hyalellas were dropped directly into the solution. On the theory that the reversal is due to the chemical changes in the tissues, the reverse of this relation would be expected.

Jennings's paper [11] is devoted to a discussion of the method of applying the principles of physics and chemistry directly to the analysis of behavior, as contrasted with the method of first analyzing behavior into its component factors, with the view of later resolving these still further and perhaps finally in terms of physical and chemical laws. The author considers the latter method the more feasible.

A detailed study was made by Kribs[50] of the reactions of Æolosoma to chemical stimuli of various kinds and degrees of strength. Attention was paid to the variability of the reactions, the influence of previous stimuli, and the condition of the organism. There is a final section devoted to a discussion of the general bearing of the results.

Positively phototactic Daphnias and Balanus nauplii, when exposed to the light of a spectrum, were found by Loeb and Maxwell[51] to congregate most abundantly in the green, as was found to be the case also with Chlamydomonas.

A part of McClendon's paper[52] is devoted to a description of the adaptations of two crustaceans, an Alpheus and a Trypton, which show certain similarities, presumably due to their similarity of habitat. The other part of the paper is devoted to an account of the behavior of an anemone, Cradactis, which commonly lives in crevices among the rocks. Light causes Cradactis to creep away by movements of its foot, or by turning over and crawling on its tentacles. The contraction of peculiar frond-like outgrowths of the tentacles at night and their expansion during the day is attributed to their positive phototaxis.

Mast[53] finds that a sudden increase of light intensity inhibits the movements of Amoeba, but its activities are resumed after continued exposure. Amoeba moves away from the light in a fairly direct path, and its orientation is determined by the inhibition of pseudopod formation on the more illuminated parts. There is no evidence that the direction of light *per se* has a directive effect on the movements of the animal. Blue light is the most potent in inducing phototaxis, while violet, green, yellow, and red have in general little effect.

Moore[55] holds that the righting movements of the starfish are not determined by gravity, but by the "positive stereotropism of the tube feet." Which arms are employed in righting depends upon their size, any injury the arms may have received, and any initial twist they may have. The starfish studied showed no evidence of learning to use a certain arm, but they could be compelled to use certain arms by injuriously irritating the others.

Experiments were carried on by Morse [56] with *Littorina litorea*, *Littorina rudis*, and *Ilyanassa obsoleta*, in order to test the conclusion of Bohn that the two former species show periodic changes of phototaxis synchronous with the rise and fall of the tides. Although the sense of the response showed certain daily changes and certain modifications of a longer interval, there were no changes observed which corresponded with the rhythm of the tides.

Parker's paper [57] contains a record of the first serious attempt to study the behavior of sponges in detail. While a sponge is capable of performing only a very few inconspicuous acts, its behavior is of especial interest on account of the absence of a definite nervous system. The oscula or excurrent openings slowly close on exposure to air, or when subjected to injurious mechanical stimulation, or to stimulation by chemicals. The currents produced by the collared cells set only in one direction; they become slow at a low temperature, but they are at first accelerated in water deprived of oxygen, although they afterward became slower and finally cease. The ostia or incurrent orifices close in solutions of ether, strychnine, and chloroform, but open in warm or deoxygenated sea water and in certain solutions of chemicals. They are comparatively unaffected by mechanical stimuli. Injuries have no effect on the ostia or oscula unless when very close to them. Transmission of impulses occurs only over very short distances, and there seems to be little or no coordination between the action of the various parts. The final section of the paper contains a discussion of the origin of the nervous system.

Polimanti [58] describes some experiments in which hermit crabs bearing the anemone Adamsia were placed in an aquarium with the cephalopod *Eledone moschata*. Although the Eledones repeatedly came in contact with the anemones and as often recoiled from the sting of the nettling cells, they gave no evidence of learning to avoid the irritating objects. The author concludes that memory in these cephalopods is very feeble, if it exists at all.

Von Prowazek's book [59] contains a valuable general account of the physiology of the Protozoa, including their reactions to various kinds of stimuli

Experiments were made by Rose [60] upon the various tropisms of *Daphnia longispina.* The ordinary positive reaction of this species to light of moderate intensity can be made more vigorous by the addition of small amounts of various acids and urea. The Daphnias remain positive in NaOH and $CaCl_2$, but the reaction is enfeebled in KCl. The author also studied the influence of age, light intensity, and temperature on phototaxis. Vertical displacements were found to follow sudden changes of light or of temperature. Galvanotropism, which is very weak in Daphnia, was found to be quite strong in Gammarus, the specimens swimming to the negative pole.

Following an account of the normal feeding reactions of Stentor, Schaeffer [61] describes the results of several feeding experiments to test the power of discrimination between different substances. Of the various materials swept into the gullet of cilia, Stentor takes in only certain kinds. Others are rejected by a quick reversal of the stroke of the cilia. The organism discriminates more readily when nearly satiated with food. When hungry it may ingest carmine and other indigestible materials, and behave differently in several other respects. Stentor apparently does not learn by experience to improve its selection of food. Schaeffer repeated the experiments of Metalnikow, on the basis of which it was claimed that Paramoecium learns by experience to select its food more advantageously, and obtained contrary results. No true learning was found in either of the species studied.

The article by Simroth [62] is devoted to the discussion of previous papers, and contains no new observations or theories on this puzzling subject.

LITERATURE FOR 1910 ON THE BEHAVIOR OF SPIDERS AND INSECTS OTHER THAN ANTS

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TROPISMS

Mitzmain [74] concludes that the rodent flea is positively phototactic in the early larval stages and negatively phototactic in the late larval and adult stages. This induction was the result of observing the reactions of the fleas upon the rodents, and in the following experiment. A large number of fleas were placed in a test-tube, the mouth closed with the thumb and the tube held horizontally with the mouth away from the window. All of the fleas jumped away from the window. When the tube was reversed so as to have the mouth facing the window the thumb could be removed without the fleas' escaping from the tube. All would bound away from the light. When a flea was placed within half an inch of the opening of the tube and headed in that direction it did not escape, but turned about and jumped away from the light. Even when the mouth of the tube was tilted downwards the flea did not escape. This experiment seems to indicate a real tropism, but one cannot help regretting that it was not performed in a wide rectangular rather than a narrow cylindrical enclosure; for in a narrow cylindrical cage even those fleas that jumped obliquely sidewise would be forced to land as though they had jumped directly away from the light. The movements of a flea are so rapid that one is practically forced to judge the direction of the movement by connecting the point of ending with the place of beginning.

Loeb claimed that, in water, blow-fly larvae are positively geotropic, but not so under any other conditions. Recently Mast [73] has conducted a series of well planned experiments, in both air and water, which militate against this induction. In the air experiments, the larvae were placed in glass jars. The small larvae moved about in every possible direction; the larger larvae crawled upwards, but frequently turned and started in other directions. When such larvae approached the horizontal, either they fell to the bottom, or each time the posterior end was raised in the process of looping, it swung downward somewhat, thus producing an orientation with the anterior end up. To test their reactions in water, larvae six millimeters long were placed in a glass jar containing water twenty centimeters deep. All of the larvae reached the bottom, but there was no evidence of either swimming or orientation; in many cases the longitudinal axis was nearly horizontal. From these experiments, Mast concludes that blow-fly larvae do not react to gravity either in the water or out of it. According to Loeb's definition of a tropism, this conclusion is sound.

McIndoo[72] has made a careful study of *Troglohyphantes* (*Willibalda*) *cavernicola* Keyserling and *Meta memardi* Latreille, two spiders inhabiting the caves of Indiana. The first form, which is often blind, lives in total darkness; the other form, which always has eyes, lives both in total darkness and in twilight. When the light of a carbide bicycle lamp was flashed upon these spiders, in the cave, the *Troglohyphantes* made no response; but the *Metas* darted away into the darkness. For thirty days a series of laboratory experiments to test the responses of these creatures to light were conducted upon specimens enclosed in glass bottles and in glass tubes. The closed end and the lower half of each such vessel was covered with black carbon paper; the open end was securely closed with an air-tight cork stopper. One specimen, with one or two drops of water, was placed in each receptacle, which was then placed on an inclined rack in a south window. These cages were occasionally rotated, so as to have the light strike the eyes of the spiders, and, at intervals, the dark paper was transferred to the cork end of the tubes. The adult *Metas* were always found in the dark end during clear and cloudy weather, and in the light end when it was dark. The spiderlings of *Meta* remained in the dark end one-half of the time during clear weather and one-third of the time during cloudy weather. When it was dark, these spiderlings spent most of the time in the light end. Twenty-six per cent. of the *Troglohyphantes* examined had no external eyes, and the remainder had eyes varying from mere pigment flecks to normal eyes. It was found that the more degenerate the eyes the greater the negative phototropism. By negative phototropism the author merely means avoiding the light.

SENSATIONS

1. *Vision.*—By the following experiment Mitzmain [74] has proved that the rodent fleas, in selecting a home, are not guided by the color of the hair. Three pure white and three pronouncedly black guinea pigs were placed in a large cage, the bedding of which was infested with the fleas. Forty-eight hours thereafter all of the rodents were removed simultaneously, and a census of the fleas taken immediately. The white animals yielded eleven, ten and five fleas respectively; the dark ones eleven, seven and four.

The aim of Turner's paper [82] is twofold: to see if, in the field, bees can be trained to respond to colored artefacts, and, after a bee has thoroughly learned to collect honey from an artefact of a certain color, to see if it can select artefacts of that color from numerous other artefacts of a different color; first, when the artefacts to be selected contain honey and the others do not; second, when some of each kind contain honey; third, when none of the artefacts contain honey; fourth, when the brightness content of the artefact to be selected is changed without altering the hue. In furthering the first aim, honey was placed on discs of a certain color and exposed in a field from which a large number of bees were collecting honey. At first these discs were not attended to; but after a lapse of several hours a few bees began to collect from them. After a few bees had acquired the habit of collecting from discs of a certain color, three different series of experiments were conducted; one with discs, one with cornucopias, and one with small boxes, each provided with a small opening. In each of these series a large number of artefacts of two colors, half of which were of the color of the discs from which the bees had learned to collect honey, were scattered promiscuously among the flowers from which the bees were foraging. The artefacts of the color from which the bees had learned to collect honey were supplied with honey, the others were not. All of the artefacts containing honey were visited by numerous bees; no bees visited the other artefacts. Control artefacts of the color from which the bees were collecting honey were well supplied with honey and placed in portions of the field where the bees had not been trained to feed from artefacts. Although the bees were numerous, these artefacts were not visited. At intervals artefacts of the color from which the bees had not been trained to forage were supplied with honey and scattered among the others. As a rule these were not visited. At the close of both the second and third series of experiments, all of the artefacts were removed from the field; and two artefacts, one of each color, both new and neither containing honey, were exposed in the field. In a few minutes, the artefact of the color that had formerly marked those that contained honey was completely packed with struggling bees. No bees entered the other artefact. In each series the artefacts were distributed in both the sunshine and the shadow. All were equally visited by the bees. Since the brightness content in the two cases was different while the color was the same, it was concluded that the bees were reacting to color as such. It is thought that these experiments prove that bees can discriminate between colors.

A month after the appearance of the above paper by Turner, Lovell's contribution to the same discussion [70] was published. The conclusions of the two papers are practically the same; but the methods of experimenting are different. Lovell's work is a repetition, with slight variations, of the experiments recorded by Sir John Lubbock in his book on "Ants, Bees, and Wasps," which was published about thirty years ago. Colored slides were made by backing small slips of clear glass with colored paper or the colored parts of flowers. A bee was trained to collect honey from a slide of a certain color. After it had made numerous visits to that slide, the slide was placed, along with one or several slides of different colors, on a support that was exposed to the bees,and the order of the slides changed frequently. All of the slides were supplied with honey. The following colors were used: blue, red, yellow, white, black, colorless, purple, orange, green. In most of the cases the bees continued to forage from the color from which they had been trained to collect honey. In some cases, however, the bees, at first, acted as though they were seeking a certain color; but after a few trips, began to collect indiscriminately from any of the slips. From these experiments the author draws the following conclusions: "Bees easily distinguish colors whether they are artificial (paints, dyes, etc.) or natural ('chlorophyll') colors. Bees are more strongly influenced by a colored slide than by one without color. Bees which have been accustomed to visit a certain color tend to return to it habitually—they exhibit color fidelity. But this habit does not become obsessional, since they quickly learn not to discriminate between colors when this is for their advantage." These experiments were well conducted; but no precautions were taken to be sure that the responses were really to hues and not to grayness.

Under a stone, Petrunkevitch [77] found a male and a female *Dysdera crocata* which he placed in a glass dish containing earth, separating them by means of wire netting. When the netting was removed, they met face to face in a threatening manner, but did not fight. While the female was digging a hole and lining it with silk, the male came near and, according to the author, was evidently watching her. When about to mate the male and female met face to face. The male crept under the sternum of the female and grasped her firmly by the petiolus with his mandibles, the fangs of which were folded, and embraced her with his legs. The female, who made no objections to these overtures, lay down and the male, while continually patting her with his third pair of legs, applied his palpus. Coitus lasted five minutes. During the whole of the time the back of the male was in contact with the sternum of the female. In spite of Prof. Montgomery's objections, the author maintains: "I repeat, therefore, that sight is the only sense of sex recognition in hunting spiders. After sex has been recognized, courtship begins, and touch is the chief means by which the male excites the female and tests her willingness to accept him." To an unprejudiced student of animal behavior who is acquainted with Montgomery's point of view, the mere fact that this spider stood at attention and then reacted in a definite way does not seem sufficient warrant for the universal assertion that sight is the only sense of sex recognition in hunting spiders. Since, in a paper* published several years ago, Petrunkevitch has proved that the structure of the spider's eye is such as to permit the formation of images, one is justified in assuming that that spider saw the female in front of which he was standing. But this does not warrant the assertion that all species of running spiders behave in the same way. Montgomery [75] admits that in the attids and in the lycosids sight plays a considerable part in sex-recognition; but holds that it plays no such rôle in other spiders. He contends that touch plays the most prominent rôle in sex-recognition of spiders, and he records observations in support of his contention. Granting that *Dysdera crocata* has visual images, it must also be admitted that the experiment described by Petrunkevitch does not warrant the universal statement made by him.

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* Petrunkevitch, Alex., "The Sense of Sight in Spiders." *Jour. Exp. Zool.*, 1907, v, 275-310.

Graenicher [68] has furnished statistics, compiled from observations made by himself in Milwaukee, Wisconsin, and by Robertson in Carlinville, Illinois, which demonstrate that the behavior of our American bee-flies (Bombyliidae) towards colored flowers is entirely unlike that of the European bee-flies. Herman Mueller claims that the bee-flies of Europe show a pronounced color preference for red, purple, and blue as opposed to yellow and white. About seventy-one per cent. of the visits of the American bee-flies were to white and to yellow flowers. These visits were made by eighteen species of bee-flies to fifty-two species of flowers belonging to seventeen families. The short-tongued bee-flies of Europe avoid flowers with concealed nectar; the short-tongued American forms make more visits to such flowers than to other kinds. Evidently the author believes that vision plays only a minor part in the life of these flies, for he writes: " Structure of flower, odor, taste, and supply of nectar determine probably more than anything else the extent to which a flower is attractive to such an insect." This pronounced difference in the behavior of related species in the same climatic zone furnishes a problem for the ecologist.

2. *Hearing.*—After reviewing the literature on the subject, Montgomery [75] concludes that there is no evidence that spiders possess the sense of hearing. Some spiders have stridulating organs, and in some cases these are confined to the males; but no tests have been performed demonstrating the spiders' response thereto.

3. *Touch.*—According to Montgomery [75] touch is the dominant sense in spiders and seems to be the special function of

the jointed spines. See Montgomery under mating and nest-building behavior

4. *Smell.*—According to Montgomery [76] the sense of smell is possessed by all spiders and seems to be distributed over a considerable area; but he does not think that it plays any part in sex-recognition.

MATING AND NEST-BUILDING BEHAVIOR

Although duration of life may not be a behavior problem, yet Philip Rau's paper [78] contains notes on the copulation and oviposition of the cecropia moth that will interest students of animal behavior. The material used consisted of sixty-nine cocoons, from which emerged forty-three males and twenty-five females. The notes upon copulation and oviposition were made upon twelve copulating pairs and four unfertilized females. The insects were kept in wire cages 11½ x 10½ x 24 inches, and observations were made at intervals of from three to six hours. It was found that the moth always mated at night and remained *in copulo* from eight to twenty-nine and a half hours. The species is strictly monogamous, it being impossible to induce a specimen that has once mated to remate. The male does not die *in copulo*, but always lives much longer than its mate. The female, which lays from 150 to 400 eggs, begins ovipositing within twenty-four hours after mating, and spends about three days in laying an average of 266.3 eggs. She usually dies before all of her eggs have been deposited and never lives more than a few days thereafter. The unfertilized females do not live in a torpid condition for weeks, waiting to mate; but from the first lead an active life, and, if a mate is not soon found, deposit their unfertilized eggs and die; their average duration of life being no more than that of those females that were fortunate enough to find mates. Since the cecropia moth belongs to the same family as the emperor moth and like it neither eats nor drinks during its imago life, students of animal behavior will be interested in the dissimilarity of behavior in the two species. According to Weismann, the female emperor moth lives in a state of torpor for weeks until fertilization is accomplished, and the male dies while *in copulo*. The male cecropia moth lives for from one to two weeks after coition. Rau cannot understand the value of this long post-connubial life of the monogamous male cecropia and wonders if it is an incipient stage of a higher adaptation or a phylogenetic vestige of a time when the long life of the male was of advantage to the species,—of a time when, possibly, the species had functional mouth parts and a polygamous habit.

Barnes [63] found that freshly emerged males of *Anisota Skinneri* copulated freely with females that had emerged the previous day. Oviposition lasted a week and each individual laid about three hundred eggs. In about a week the eggs hatched and the larvae fed upon oak leaves. There were five larval stages. Pupation occurs in the ground. In captivity, there are two broods a year.

Mitzmain [74] found that in mating the male rodent flea attached itself to the ventral side of the female, by means of its antennae, and remained more or less passive; while the female went from place to place bearing the male on her back.

Montgomery's [75] paper is an elaborate discussion of the courting habits of spiders. He gives a critical review of the work of previous writers and records numerous original observations. At the close he gives a list of the literature of the subject. Montgomery finds that the males mature earlier than the females and that they do not live longer than a year. Promiscuous mating is general; a male usually impregnates a number of females and a female usually accepts several males. Monogamy is exceptional, occurring in those cases where the male seizes an immature female by force and where the male lives in a mating nest with the female. In some cases there is no courtship (some thomasids, some lycosids); but usually there is some form of it, and this may be by either touch or by sight. In the simplest form of courtship by touch, the male taps the female rapidly with his feet until she either runs from him or becomes submissive (some drassids). In the more complicated form, the male makes signal pulls upon the lines of the snare; when the female is eager for him, she returns the signal in the same way (Theridium). In courtship by sight, which is peculiar to only a few of the diurnal forms, "the courtship movements of the male range from a simple waving of the first pair of legs (*Lycosa lepida* Keys), or the waving of these and the palpi, to much more complicated movements of these parts associated with peculiar posturings, advances and retreats, and side-wheeling" (attids). According to Montgomery, the courtship of the male is not a conscious effort of the male to display his peculiar beauty before the female, but the result of fear mingled with sexual desire. Unlike the Peckhams, he thinks the female is attracted by maleness alone and not by beauty, and that she probably yields to the more agile male. The immediate effect of the courtship on the female is the stimulation of her sexual desire by the recognition of the male. There is no arousing of the esthetic sense first and the sexual desire afterwards. The female accepts the first male who courts her and makes himself recognized as a male at the time when she is physiologically desirous. The case of *Astia*, where the Peckhams proved that the female always accepts the most ornamental of the males present, he would explain as follows: The most ornamental male is selected by the female because he is more unlike her and hence more quickly recognized as a male. Battles to the death do not occur among male spiders; but they engage in feeble conflicts, both in the presence of the female and in her absence. He does not agree with the Peckhams that these fights are for the purpose of showing off before the female. He asserts, " Sexual selection in the meaning of Darwin, and in opposition to the view of the Peckhams, has probably played no part in the evolution of secondary sexual characters." The Peckhams claim that the female spider selects the more ornamental male because to her he is more beautiful than his rival: Montgomery claims that the female spider selects the more ornamental male because he is more conspicuous than his rival. Montgomery's explanation eliminates the esthetic sense; but it does not militate against the hypothesis of sexual selection. Darwin writes*: " When males and females of an animal have the same general habits of life, but differ in structure, color, or ornament, such differences have been mainly caused by sexual selection; that is, by individual males having had, in successive generations, some slight advantage over other males, in their weapons, means of defense, or charms, which they have transmitted to their male offspring alone." If the conspicuousness of the ornamentation caused the male spider to be selected by the female, that ornamentation is just as much a "charm" as though its beauty had caused it to be selected.

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* Darwin, Charles. The Origin of Species. Appleton, 1899, vol. I., p. 110.

McIndoo [72] found the courtship of cave spiders to be similar to that of outside forms. When *in copulo* the bodies were reversed and the ventral portion of the female was in contact with the dorsal portion of the male.

See Petrunkevitch under sensation and Bueno and McDermott under miscellaneous behavior.

MISCELLANEOUS

A few years ago Pergande stated that the life cycle of *Hormaphis hamameledis*, an aphid, consists of seven generations; the first two and the sexual generation living on the witch hazel, and the other four on the black birch. Morgan and Shull [76] now state that this species passes its entire life cycle upon the witch hazel. About August the first, paraffined paper bags were placed about twigs of witch hazel that were bearing galls containing these aphids. On September the first, sexual forms were found on the leaves in the bags and on those outside. A microscopic examination of sections of migrants within the galls and of pupal and larval stages showed that these forms contained embryos that were male or female. In the open, a branch of witch hazel, bearing aphids, and a branch of birch, which was growing near it, were enclosed in the same bag. The aphids did not migrate to the birch. Unless Pergande is in error, a few degrees of latitude make a marked difference in the life cycle of this plant louse.

F. M. Webster [83] has thoroughly established the fact that *Pediculoides ventricosus*, which is usually supposed to be a beneficial mite, often produces in man a very disagreeable form of dermititis. This mite usually feeds on the larvae of several different insect pests, notably the grain moth, the wheat stalk joint worm, and the boll weevil. A few years ago it was proposed to get rid of the boll weevil by spreading this mite among them. Some enthusiasts went so far as to import a number into Texas; but some enemy, probably ants, destroyed them. It has now been shown that in Philadelphia, Baltimore, and elsewhere, several epidemics of dermititis have been caused by this mite. This fact has been established in the following manner. It was found that all who were afflicted with the disease had slept upon beds made from wheat straw that had come from a certain locality. When straw from one of these beds was placed upon a human body the disease developed. Some dust from the straw was placed upon a human body. The disease developed at once. It was found that the same straw when treated with chloroform did not cause the disease. This indicated a living organism as the cause of the disease. A microscopic examination of the dust from the straw showed that it was infested with this mite. When these mites were placed on the human body, the disease developed.

De La Torre Bueno [64] relates that the water strider *Microvelia* hibernates beneath the overhanging banks of little streams and that it breeds in early spring. Like all water striders, it is carnivorous; but when live prey cannot be found, it will feed on dead and gamey food. When near the bank, it moves with quick, short steps; but when far from shore, it makes rowing movements. The author gives a lengthy description of the bug's method of cleaning itself. At mating time the female is passive and the male aggressive. A careful aquarium study was made of the oviposition and larval life of the bug. The adults were confined to a large aquarium until they had mated and oviposited. As soon as hatched, each larva was isolated in a small individual aquarium and kept there until mature. The adults mated between August 20th and 27th and immediately began to lay. Some eggs were attached to duck weed, some were dropped upon the surface of the water; but the majority were encased in jelly and attached to the walls of the aquarium. The life cycle consisted of seven instars; one embryonic, five nymphal, and one adult. The adult, on first emerging, is creamy white. The author thinks that there may be as many as five generations a summer.

McDermott [71] has made a careful field study of the phosphorescence of the following Lampyridae: *Photinus pyralis*, *P. Pennsylvannica*, *P. consanguineus*, *P. scintillans*, *Lecontea angulata*. He describes the flash of several species and insists that its quality and mode of emission is of sufficient taxonomic value to permit the identification of the species on the wing. He thinks that the glow is related to the sexual function and that it has a protective value. He claims that the emission of the flash is under the voluntary control of the species; but gives no proof of this other than that a certain species has a variety of ways of emitting the light.

N. Criddle [65] records some field observations upon the larvae of several tiger beetles found in the neighborhood of Ameme, Manitoba. He finds that their behavior is much influenced by the climate. When the fall is dry and hot, they go into winter quarters much sooner than when it is cold; and the hot summer days are much preferred for commencing the winter home. He also reports that the larvae at that place differ from the larvae of similar species of the Chicago neighborhood in spending two winters in the larval stage instead of one. He attributes this to the fact that in the summer time there are long periods of inactivity and no appreciable growth, when the larva closes up its burrow and fasts. This is not a case of perfect aestivation, for a few open up their holes at night, cast out dirt and then reseal them.

Sanders [81] has discovered that the larva of *Amara caranata* is a host of *Disogmus pubescens.* The parasite breaks through the ventral wall of its host and forms chrysalids attached to the posterior end of the larvae. The chrysalids were found between the tenth and the fourteenth of May, and the adults emerged on the twenty-eighth. He thinks this is the first time that the host of this species has been discovered.

By the following experiments Mitzmain [74] demonstrated that the rodent fleas are not attracted by meat as a bait. Twelve pieces of tanglefoot fly paper were arranged in pairs, in three rooms of a dwelling that was infested with fleas. Each paper of any pair was equally illuminated and one sheet of each pair was supplied with fresh cow's liver. At the end of the third day the papers were collected and the number of fleas on each recorded. Four months later the experiment was repeated. In the first experiment, nineteen fleas were found on the blank paper and fourteen upon the one that supported the meat; in the second experiment, sixty-one fleas were found on each sheet of paper.

McIndoo [72] reports that the cave spiders feed on flies, myriopods, and arachnids, and that they do not drink. He attributes this failure to drink to the great humidity of the air in which they live. Scarcity of food does not entirely limit their distribution.

LITERATURE FOR 1910 ON THE BEHAVIOR OF ANTS, THEIR GUESTS AND PARASITES

WILLIAM MORTON WHEELER

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Brun [84] records a number of observations and experiments on *Formica rufa* and its subspecies *pratensis*. Portions of two *rufa* and two *pratensis* nests were placed in a bag and, after being dumped in a new locality, formed a single colony without signs of hostility. Nearly two weeks later detachments from the two original *rufa* nests, one with and the other without brood, were brought to the artificially compounded colony. The workers unaccompanied by brood were received with hostility and killed: those with brood were at once amicably adopted. From this and similar experiments Brun infers that the artificial and, to an even greater degree, the natural alliances between members of different *rufa* colonies are due to a "complicated psychically plastic activity on the one hand, in which the normal instincts are implicated partly by themselves, partly combined with one another, and partly suddenly overwhelmed or surprised ("überrümpelt") by powerful engrams; and on the other hand represent psychic contrast effects and finally even, in many cases, associations of new engrams rapidly combined with one another and with mnemic elements." Brun extended his work to the behavior of *rufa* and *pratensis* queens introduced into alien nests and to the founding of colonies by these ants. Like Wasmann, he finds that these queens from one colony are readily adopted by the workers, of other colonies, and that this is, under natural conditions, one of the methods of forming new nests or settlements. He also found mixed incipient colonies consisting of *rufa* and *F. fusca* var. *glebaria* and of *rufopratensis* and *fusca* similar to those described by Wasmann and Wheeler, showing that new colonies (not new settlements) of *rufa* and *pratensis* are formed by temporary parasitism of the queens of these ants on colonies of *fusca* or of some one of its varieties.

Burrill [85], after studying the trails of the American varieties of the slave-making *Formica sanguinea*, reaches the conclusion that these insects in their forays may suddenly change the direction of their route at will and do not slavishly adhere to an odor-trail. Observation "appears to indicate that the sense of smell may be superseded any moment by that of sight or by the individual's will to fluctuate in its adherence to scent. It appears in *sanguinea* that the sight of the many or some social responsiveness of the many (a responsiveness considered usually to be communicated through the sense of touch in the antennae) may supersede the trail scent equally well." Burrill finds, moreover, that the files of ants do not always take the shortest path between their own nest and that of the *fusca* which they are plundering, but sometimes make detours to avoid uneven or arduous paths.

Cornetz[86, 87] made an elaborate study of more than one hundred trails to and from the nest in the following North African ants: *Myrmecocystus bicolor* and its subspecies *megalocola*, *Messor barbarus* and its variety *sanctus*, *Aphænogaster testaceopilosa*, *Monomorium pharaonis* and *Tapinoma erraticum*. These trails were carefully plotted on paper, and, together with minute observations of the behavior of each ant by which they were laid down, constitute the basis of fact from which the author draws his conclusions. The species studied are distinguished as "superior" and "inferior." To the former class belong the *Myrmecocysti*, large, active ants, with well-developed eyes and ocelli. They forage singly. *Messor*, *Monomorium*, and *Tapinoma*, which belong to the inferior group, are usually seen foraging in files. The range of distinct vision in *Tapinoma* can scarcely exceed 2 mm., in *Messor barbarus* 4-5 mm., whereas in *Myrmecocystus* it is 5-6 cm. The formation of straight files in the inferior forms, from the nest to a definite food-supply and home again, is a derivative phenomenon which is preceded by the development of the trail of the individual worker, which leaves the nest, discovers the food-supply and returns without relying on any preëstablished trail. The author therefore correctly insists that the homing behavior must be studied, not on files of ants which are following a developed trail, but on the single exploring worker When such a worker is studied, she is seen to depart from the nest opening in a definite direction and, after going a short distance, to halt and move about, often in a complicated path, exploring for food. If none is found she again moves off, but in the same direction which she took on leaving the nest. She may again halt and explore, and the movement away from the nest in the original direction in a straight or sinuous trail, with occasional exploratory excursions, may be repeated several times. If food is found or if the ant's efforts are fruitless, she returns to the nest, adopting the reverse direction and omitting the exploratory movements, but never passing along the outgoing trail even when this is encountered. As a result of this behavior the ant finally lands at one side of the nest entrance. Then she begins to turn around till she recognizes the vicinity of the nest and finally enters it. This turning, which is very characteristic, is called by Cornetz "le tournoiement de Turner," and is distinguished from the other exploratory movements ("tournoiements de recherche de provende"). The straight or sinuous portions of the trail following the original direction from the nest and reversing it on the return are called "trajets de Piéron." Cornetz, therefore, rejects the conclusions of Bethe and others to the effect that the individual ant depends on her odor trail, and agrees with Piéron in believing that on her return trip she depends on her kinesthetic or muscular movements; but he maintains that these can give only a rough indication of the amount of territory covered on the outward trip. The maintenance of a given direction, even when interrupted by exploratory excursions, both on the going and returning trails, must be ascribed to an inner sense. The ant behaves, in short, "as if she contained a compass." The kinesthetic sense acts merely like a roughly constructed podometer, giving the insect a vague notion of the distance she has traveled away from the nest. That the homing ant follows a direction and not a trail is shown by her maintaining this direction even when she is lifted from her path by the wind or by the experimentor, and deposited some distance away, even if this be on the opposite side of the nest opening (Piéron's experiment). Cornetz does not, of course, exclude the ant's recognition of landmarks by means of sight, smell, or touch, or her resorting to the odor of a well-established trail under certain conditions, especially during the "tournoiements de Turner," but these are not the determining factors in the first developmental stages of the trail. The territory covered by ants of the superior genus (*Myrmecocystus*) in their foraging trips is some five times greater than in the inferior genera (*Messor*, *Tapinoma*, *Aphænogaster*, *Monomorium*) and the various "trajets" and "tournoiements" are each over a proportionally greater area. That the continual return, after the detours of exploration, to the direction of the first sally from the nest, as well as the podometric sense and the recognition of landmarks near the nest entrance all imply a kind of memory is clearly admitted by Cornetz.

Crawley [88] describes the various ways in which ants greet one another. The species of *Myrmica* merely touch one another with their antennae. In the species of *Formica* this gesture is often prolonged, especially in hot weather. These ants and the species of *Lasius* and *Camponotus* also jerk the body forwards in greeting. They do not, however, butt one another with their heads, as is usually stated, but merely touch with the antennae. These jerking movements of the head are not exhibited by *Myrmica* and *Tapinoma*. "In case of alarm, ants rush about the nest in great excitement, infecting every ant they meet with alarm, until the whole nest is aroused." Only young queens respond to the salute of the workers; "an old queen in a large nest never does."

Crawley [89] records some observations on a large colony of *Lasius fuliginosus* which, to his knowledge, had been nesting partly in an old stump and partly in the beams of a house, for ten years. The nest seems to have contained workers of *L. umbratus* (at first incorrectly identified as *L. flavus*), indicating, as Lannoy has since shown, that *L. fuliginosus* is a temporary parasite on *L. umbratus*, which is in turn a temporary parasite on *L. niger*. In the *fuliginosus* colony observed by Crawley about one ant in eight carried a small commensal mite of the genus *Antennophorus*.

Crawley [90] made several observations on the relations of the little isopod *Platyarthrus hoffmanseggi* to various ants. He found that most species are hostile and devour or drive away these crustaceans, but that *Lasius flavus* and *L. niger* seem to be very tolerant of them. As a rule "*L. flavus* receives *Platyarthri* from nests of its own species and from nests of *L. niger* and others without taking any notice of them. These small blind woodlice pass their whole existence in ants' nests, and when about to moult or produce offspring, are found in small cells of earth made in the walls of the nest, where they remain for some time, finally breaking their way out." Apparently the cells are made by the ants, since these insects were seen carefully plastering earth around the crustaceans.

Crawley [91] records a number of observations on female ants introduced into alien colonies of the same species, with results which do not differ materially from those obtained by several other observers. He mentions the occurrence of short-winged females of *Lasius niger* and *L. flavus* and gives a few interesting observations on *L. fuliginosus*, which has its nuptial flight late in May or early in June. Not all the males and females, however, leave the nest at this time, as some of them were found by Crawley in or near the nests as late as September 14 and October 13. At Ouchy, Switzerland, he saw workers of *L. fuliginosus* pulling deälated females into their nests. These females apparently had flown originally from this same nest.

Crawley [92] exhibited to the South London Entomological and Natural History Society a colony of workers of *Lasius niger*, which in 1908 had adopted a female *L. umbratus*. "Up to this autumn (1910) the only ants which had come to maturity in the nest were pure *Lasius niger*, thus confirming Reichenbach's experiments (Biologisches Centralblatt, July 15th, 1902, p. 461), that *Lasius niger* workers are able to produce workers parthenogenetically." Crawley found that a similar colony dating from 1896 gave similar results (Science Gossip, May, 1900).

Donisthorpe [93] records several observations on colony formation in ants, confirming the observations of Wheeler, Wasmann, and others. A female *Formica rufa*, to which workers of *F. rufibarbis* var. *fusco-rufibarbis* were admitted in an artificial nest, struggled with and killed a few of the latter, but was eventually adopted by the survivors. The paper concludes with a few notes on myrmecophiles. The pseudoscorpion (*Chernes scorpioides*) found "literally in thousands" in *F. rufa* nests in Leicestershire, is treated with indifference by the ants.

Donisthorpe [94] looked for a response from ants in captivity to the Galton-Edelmann whistle, which, tested by the sensitive flame, gives off vibrations far above the human range of 40,000-50,000 per second. The ants, however, "never appeared to notice anything at all."

Donisthorpe[95] records a number of miscellaneous observations on *Formica rufopratensis*, *sanguinea*, *exsecta*, *rubescens*, *Tapinoma erraticum*, etc., and on a long list of myrmecophiles found in the nests of these ants.

Donisthorpe[96] gives the results of several experiments on the behavior of ants of two species brought together in the same nest; especially the behavior of queens of *Formica sanguinea* introduced into small colonies of *F. fusca* or of *F. fusco-rufibarbis* with pupæ, with a view to throwing light on the methods of colony formation. The results obtained with the queens of *sanguinea* and worker *fusca* agree closely with those described by Wheeler, Viehmeyer, and Wasmann. The queen attacked the workers and was often killed. In some cases, however, she killed all or nearly all the *fusca* workers, collected their pupæ and stood guard over them. In two experiments the queen became friendly with a few of the surviving workers. In numerous experiments with queens of *sanguinea* and workers of *F. fusco-rufibarbis* Donisthorpe found that the queens were always killed, usually on the day they were introduced into the nest. This he attributes to the fact that *fusco-rufibarbis* has a much fiercer and more pugnacious disposition than the typical *fusca*.

Emery[97], after a survey of the methods of reproduction in the different groups of social insects, concludes that the "Dzierzon rule, which is valid, with rare exceptions, for the social and for many of the nonsocial Hymenoptera, should be understood as follows: *a*. The female produces eggs which are pregamically determined as male. *b*. The male produces spermatozoa determined as female. *c*. In fecundation the female character of the sperm is dominant. The Hymenoptera that follow Dzierzon's rule are, however, extreme cases, which are certainly connected with the more indifferent cases in insects whose ova are pregamically determined as male and female." In connection with these conclusions Emery discusses the extraordinary results obtained many years ago by Fabre in his studies on the determination of the sex of the egg in solitary bees of the genera *Osmia* and *Halictus*.

Emery[98] gives a brief survey of polymorphism in the social insects (wasps, bees, ants, and termites). The production of the worker form is held to be the result of inadequate feeding of the larva from which it develops, directly and clearly so in the wasps and bumble-bees, but more indirectly and obscurely in the honey-bees, ants, and termites. The disappearance of the worker phases in certain small and permanently parasitic ants like *Anergates atratulus* is explained as the result of overfeeding of all the female larvæ, coupled with their small size, and not as due to the uselessness of the worker caste.

Jacobson [99] describes the habits of a well-known Indomalayan ant, *Pheidologeton diversus*, and of a singular fly, *Bengalia latro*, which deprives it of its food. The *Pheidologeton* has highly polymorphic workers, varying from small individuals with small heads to huge soldiers with large heads and mandibles. The species is omnivorous, eating both insects and seeds. It forages in long files which construct beaten roads from the crater nest, or even covered galleries 2–2.5 cm. broad and sometimes 50 m. long. The large soldiers rarely accompany the files of workers, but will defend the nest when it is broken open. They also probably husk the seeds which are carried into the nest by the small workers. The *Bengalia* stations itself near a file of foraging ants and pounces on the workers as they return laden with food, wresting it from them with great skill and celerity and devouring it, if it is of animal nature, but rejecting it if it is vegetable. According to Jacobson the fly can see a food-laden ant at a distance of at least 15 cm. The *Bengalia* and two other *Diptera* (*Idia luteigaster* and *I. discolor*), which hang about the *Pheidologeton* nests, but without revealing their intentions, are described in a separate paper by de Meijere [21].

Kneissl [100], after giving an interpretation of the synonymy of the peculiar myrmecophilous mite *Uropolyaspis hamuliferus*, records several observations on its behavior. As a nymph it is invariably attached to the basal edge of the tibia of one of the middle or hind feet of *Lasius niger* by means of an anal secretion, in such a position that the anterior end is always turned outward and slightly upward with respect to its host. Here it sheds its skin and becomes an imago. In this stage its food is unknown but probably consists of offal; during its nymphal stage, however, it is licked and fed by the ants. Its transformation, according to Kneissl, depends on the frequency with which it is licked. The imago is regarded as a synœkete, the nymph as a "pseudosymphilic ectoparasite." Attention is called to a singular organ situated between the anus and fourth pair of legs, which probably enables the *Uropolyaspis* nymph to turn to the right or left while it is being licked, without danger of becoming detached from the hard anal secretion that secures it to the tibia of its host.

Krüger [101] finds that the blind myrmecophilous beetle *Claviger testaceus*, which lives with *Lasius flavus* and *L. niger*, possesses two kinds of glands which are lacking in non-myrmecophilous beetles, and that its dermal glandular system is more highly developed. These glands give off an ethereal secretion which is probably similar to that emanating from the ants or their brood. This, according to Krüger, insures the beetle's adoption in the nest, and leads the ants to feed and care for it. The beetles attach themselves to the ant-larvae and, although Wasmann claims to have seen one eating a larva, Krüger believes that they really eat the food which is placed by the ants on the mouths of their larvæ, and that the presence of *Claviger* is not injurious to colonies containing abundant brood. Although often fed by the ants, after the manner of a true symphile, *Claviger* is nevertheless still able to feed independently. Krüger, like Bargagli and Hetschko, shows that the beetle, when isolated from the ants, may subsist for many days on dead flies.

Lea [102] describes a large number of new myrmecophilous, termitophilous, and melittophilous beetles from Australia, but gives few notes on their behavior, though he is careful to mention their hosts by name. As would be expected, most of the species are *Staphylinidœ* and *Pselaphidœ*, though several remarkable Histeridæ, especially of the genus *Chlamydopsis*, are included. One of these (*C. longipes*) has become very ant-like in appearance through a singular lengthening and attenuation of the legs.

Marsh [103] observes that a Colorado ant which he calls *Formica cinereo-rufibarbis* (probably *F. fusca* var. *neoclara*) protects aphids on melon vines by preying on the enemies of these insects. The ants were "repeatedly observed carrying away adults of the convergent lady-bird (*Hippodamia convergens* Guér.), the nabid bug *Reduviolus flavus* L., and a species of *Chrysopa*. The lady-bird larvæ apparently were not molested, while the beneficial syrphid larvæ were objects of special attack, and it was not unusual to see as many as ten or twelve larvæ being carried away from a single vine at a time. Wherever the ants were abundant, the syrphid larvæ were noticeably reduced in number, and the aphids thus had a better chance of increasing." Marsh found little evidence for the belief that *Formica* harbors the aphids or their eggs in its nest during the winter or distributes them over the vines.

Neger [105] studied the harvesting habits of *Messor barbarus* on the island of Arbe, in Dalmatia. This ant was found to collect and store in its nest the seeds of a great number of different plants, but often it seemed to mistake empty seed-pods, husks, or other small objects for seeds and carried them into the nest. These, however, were rejected by the more discriminating individuals within the nest and carried out to the refuse heap. The germination of the seeds is not prevented by the ants, as so many observers have maintained since the days of Pliny. When this process fails to occur, it may be due to the fact that many seeds have to remain quiescent for a long period before germination, even when they are kept moist, while others even require exposure to the light. That germination was not prevented was seen in all cases where seeds were carried out by the ants and left to dry, usually on the refuse heap, for such seeds, according to Neger, had all germinated. After drying they were carried back into the nest. Neger believes that germination is really favored by the ants in order to bring about the dehiscence and thus to facilitate the removal of the often very tough or hard seed-coats. The drying, moreover, kills the seeds. That this is not a malting process is shown by the fact that the seeds are not permitted to germinate long enough to convert the starch into maltose. Neger made the interesting discovery that *M. barbarus* kneads the husked seeds into little pellets of dough, which he calls "ant bread-crumbs." These are also dried in the sun (sterilized?) when they become moist and are again carried into the nest. Apparently these crumbs contain a fungus (*Aspergillus niger*) the amylolytic and proteolytic action of which renders them more easily assimilable by the ants and their larvæ. *M. barbarus*, like the American harvesters of the genus *Pogonomyrmex*, mows down the plants growing on its nest, but it carries their leaves down into the galleries, for what purpose Neger was unable to determine.

O'Brien [106] confirms the observations of former authors who have studied the habits of the green tree ant (*Œcophylla viridescens*) of Queensland, in so far as these relate to the use of the larvae in spinning the silken web with which the leaves forming the nest are held together. He also observed the bridges or chains which these ants make of their own bodies in order to draw the leaves together and to hold them in place, while other detachments of workers are moving the spinning larvæ back and forth like shuttles across the gap. These bridges seem to be very stable. One of them was carefully watched for a period of 80 minutes, during which time none of the ants was relieved.

Pierce [107] makes a few observations on the Texan harvesting ants *Pogonomyrmex barbatus* var. *molefaciens* and *Ischnomyrmex cockerelli*. He claims to have found these two ants living together amicably, an observation open to considerable doubt. On the nest crater of *P. molefaciens* he found seeds of a common grass (*Andropogon torreyanus*). This ant is most active during the warmest part of the day, but remains in its nest when the temperature rises to 114° F., with a ground temperature of 140° F. At such times the greatest activity is in the morning or towards sunset. "It is also noticeable that the foragers are not very far from the nests on cloudy days, and when a rain seems imminent the ants are clustered within a few inches of the entrance to the nests."

Piéron [108] reviews in considerable detail the general subject of social symbiosis in ants, devoting half of his article to an account of the facts, the other half to a discussion of the various hypotheses which have been advanced within recent years to account for the phylogenetic development of temporary and permanent social parasitism and slavery (dulosis). In the main he accepts Wasmann's views, even where these involve erroneous interpretations (as in the case of the supposed dulosis of the American *Formica specularis*), as opposed to the views of Wheeler, Emery, Santschi, and Viehmeyer, and derives the predatory from the parasitic types of colony formation. The author's views, however, are vague and of little importance, probably because he has made no observations of his own on the subject he discusses.

Santschi [109] calls attention to the fact that monandry, or fecundation of the female by a single male, though assumed to be the normal occurrence in the honey bee, owing to the tearing away of the male genitalia during the nuptial flight and the impossibility of further impregnation, has not been proved to be the normal occurrence in ants. In these insects, on the contrary, polyandry seems to be the rule. Forel long ago (1874) observed the fecundation of a single queen by several males in *Lasius flavus*, *Leptothorax acervorum*, *L. tuberum*, *Myrmica scabrinodis*, and *M. lobicornis*. Santschi describes in detail the same occurrence in *Monomorium salomonis* and *Solenopsis lou*. The queen of these ants during her nuptial flight is surrounded by several males, each of whom mates with her for less than a minute. In *M. salomonis*, after mating for 30–40 seconds the queen was seen to drive the male away by biting the tip of its abdomen, and then submitted to another male. Santschi believes that polyandry is the rule, especially in species with small males, and that it is a means of filling the spermatheca of the queen with a large quantity of sperm. This is probably a necessity in species which produce very populous colonies from the ova of a single queen, but it does not explain the conditions in *Leptothorax* and *Myrmica* which, though polyandric, nevertheless live in small colonies and sometimes have several fertile queens in a colony.

Schimmer [110] replies to Wasmann's criticism [118] of his views on the "instinct of toleration" in ants. Wasmann has long been of the opinion that the toleration of certain myrmecophiles and parasites by ants is due to a possession by the latter of special "symphilic instincts." The existence of these is denied by Schimmer, who holds, especially in the cases of the tiny cricket *Myrmecophila* and the beetle *Dinarda*, which he has studied most thoroughly, that the adaptations to myrmecophily are on the part of the myrmecophiles themselves and not of their hosts. A "physical correlation" on the part of the hosts could be produced only by a selective action of the myrmecophiles, and this has not been shown to exist.

Schmitz [111] discusses the relations of the myrmecophilous beetles of the genus *Atemeles* to their hosts. Like the American *Xenodusæ*, the European species of *Atemeles* are heterœcious, i. e., they have two hosts, since they live and breed with species of *Formica* during the summer and hibernate with species of *Myrmica* nesting in the same localities. Wasmann has given various interpretations of these host relationships. In 1899 he believed that the *Atemeles* could not breed with *Myrmica*, because this ant has naked pupæ, and therefore did not have the habit of burying its larvæ and with them the larvæ of the *Atemeles*. Later (1906) he regarded *Myrmica* as the primary and *Formica* as the secondary host of *Atemeles* at the present time, but the reverse as having been the phylogenetic relation. Both of these views were held simultaneously by Wasmann in 1908. Schmitz finds that *Atemeles paradoxus* in a nest of *Formica rufibarbis* does not require the aid of the ants during pupation, but may itself enter the earth and pupate. Schmitz therefore rejects Wasmann's first hypothesis, but accepts the second and also Wasmann's opinion that it is only the *Atemeles* pupæ which are forgotten and are not unearthed by the ants, that are able to develop into the adult beetles. This hypothesis seems also to have been invalidated by Wasmann himself when he observed workers of *F. rufibarbis* standing guard for two weeks over a place where they had buried some mature *Atemeles* larvæ. The attitude of the ants was such as to suggest very forcibly that they remembered the spot in which they had deposited their guests. See also Wasmann [37].

Vickery [112] confirms the observations of Walsh, Forbes, Webster, Kelley, Phillips, Ainslee, and others on the relations of *Lasius niger* var. *americanus* to the corn and root-aphid (*Aphis maidiradicis*). The ant collects the winter eggs of this injurious aphid, stores them in its nest during the winter and in the spring distributes the hatching young over the roots of the growing maize. The ants then live very largely on the sweet excrement of the aphids. Several other ants may bear similar relations to this same aphid. Vickery also describes another aphid (*A. middletoni*) which has been confounded with *A. maidiradicis*, but which lives on the roots of a common weed, *Erigeron canadensis*, and other composites and has an even larger list of attendant ants.

Viehmeyer [113] describes the myrmecophilous organs of the caterpillar of the lycaenid *Catochrysops cnejus*, namely, the slit-shaped median pore in the antepenultimate abdominal segment, the pair of eversible tubules on the penultimate segment, and the small tufted hairs which cover the surface of the caterpillar after its first moult and appear simultaneously with the opening of the pore. These hairs, which are densest near the pore, are supposed to be tactile and to apprise the caterpillar of the presence of the ants; the eversible tubules are probably alluring organs which diffuse some volatile substance that serves to attract the ants, and the pore certainly emits a sweet liquid which is eagerly imbibed by the ants. The ant which normally attends *Catochrysops cnejus* is *Polyrhachis dives.* According to Viehmeyer, " Green's supposition that the pupation of the caterpillar takes place in the ant's nest appears to be without foundation." The paper concludes with a list of 24 species, representing 19 genera, of myrmecophilous Lycænidæ from the Indomalayan region.

Viehmeyer [114] describes the peculiar pupæ of a Philippine lycænid (probably a species of *Arhopala*) which were found attended by ants (*Camponotus quadrisectus*). The nests of these ants are situated on trees and consist of masses of earth tunnelled with galleries and overgrown with epiphytes like the "ant-gardens" described by Ule for the Amazon region. The lycænid pupæ were in special cells that had been constructed by the ants. In these pupæ "dorsally, on the seventh abdominal segment, exactly in the place where the lycænid larvæ have the opening of the secretory gland, there is situated an oval, chitinous, crater-shaped cavity 1.3 millimeter in length and 0.7 millimeter in width." As this cavity is connected with the inside of the pupa, Viehmeyer infers that it produces some secretion like that produced by the larva from the gland in the same situation. " We have undoubtedly the peculiar spectacle of a lepidopterous pupa acting as a food purveyor to ants, as it gives them from a chitinous crater the secretion of two glands (in analogy with the caterpillar) at least during the first part of the pupal stage." Viehmeyer has seen a similar but smaller and more vestigial organ on the pupa of *Arhopala amantes* of India. This pupa seems to represent "the missing link between those lycænid pupæ which are simply permitted to remain, or are more or less accidentally found, in ant nests and those which we may legitimately assign as dwelling in ant colonies."

Viehmeyer [115] finds the methods of colony formation by young queens of the slave-making *Formica sanguinea* to be more numerous than had been supposed. He believes that this ant is primitively predatory and that its slave-making and socially parasitic habits have arisen directly from its predatism and not from a previous stage of adoption by *F. fusca* workers.

The queens of *sanguinea* may establish their colonies by robbing and rearing the pupæ of *fusca*, by allying themselves with queens of *fusca* or by being adopted by *fusca* workers. Ontogenetically these three types of dependent colony formation represent three different adaptations to conditions which may happen to prevail at the time when the *sanguinea* queens have to be assisted by *fusca*. Phylogenetically the three types represent successive stages of degeneration in the social parasitism of *sanguinea*. Viehmeyer opposes Wasmann's contention that the predatory parasitism of this ant has had its phyletic origin in adoption of the characters displayed by the female *Formicæ* of the *rufa* group.

Viehmeyer [116] agrees with Emery and disagrees with Wasmann in deriving the adoptive type of colony formation, like that of the acervicolous species of *Formica* (*F. rufa*) and allied forms of this group, from the predatory type of species like *F. sanguinea*. He does not believe that the queen of *rufa* exhibits a mingling of dulotic and predatory instincts. These are merely maternal in character. The dulotic condition of *sanguinea* may have developed directly, as it has in all probability developed in *Harpagoxenus*, from the thieving (cleptobiotic) proclivities which are so common among ants.

Wasmann [117], after many years of observation in Luxemburg, has come to the conclusion that several beetles of the genus *Staphylinus*, especially *S. stercorarius*, have taken to preying on ants. In other words, these beetles have become synechthrans, at any rate in certain localities. Single individuals of *S. stercorarius* were regularly found in nests of *Tetramorium cæspitum*, especially during the summer. On being placed in an artificial nest of this ant, the beetle was at first attacked by the workers, but succeeded in escaping by burying itself in the earth. Later Wasmann saw it emerging from its hiding place and preying on the brood and the ants themselves. *S. fossor* seems to bear similar relations to *Formica sanguinea*.

Wasmann [118] reviews and discusses his own often published views on the symphilic relations of ants and myrmecophiles, and reiterates his belief in special "symphilic instincts," which impell ants and termites to react in peculiar and often selective ways towards their guests and parasites; as opposed to the views of Escherich, Wheeler, and Schimmer, who regard symphily as a form of parasitism in which the adaptations are practically all on the part of the parasites. Wasmann concludes that "the symphilic instincts of ants and termites are phylogenetically acquired differentiations and specializations of the general brood — and adoptive instincts of these social insects. Through their hereditary relation to the adoption and nurture of certain true guests they are to be regarded as specialized instincts. Assumption of these instincts is necessary to an understanding of the facts." Wasmann reviews the various adaptive characters of the symphiles (trichomes, exudate organs, antennal structure, etc.), and concludes that these could be developed only by a kind of selection, which he calls "amical selection," exercised by the host ants, and that this kind of selection is merely a function of the symphilic instinct. Amical selection is supposed to be built on natural selection and to heighten and perfect the adaptation of the symphile to its host. From the standpoint of the host, however, amical selection is supposed to be independent of, and to be even inimical to, natural selection.

Wasmann [119] reviews Holmgren's recent studies on termites with special reference to his theory of the rôle of the exudates in the behavior of these insects. The exudate organs and tissues were first described by Wasmann in 1903 in the guests of ants and termites. The tissues consist of fatty or adipoid elements, which seem to represent merely a modified portion of the corpus adiposum, and give off through the cuticle to the surface of the body a thin liquid which resembles and in some cases may actually be blood plasma. Exudate tissue has now been found by Holmgren also in the termites themselves, and is most highly developed in the queen. He regards the exudate as a nutritive substance which is eaten by the termites, and owing to its different constitution in the different castes, sexes, and developmental stages of the individuals in the colony acts as a varying stimulus which causes the insects to vary their behavior adaptively. Thus he maintains that the exudate tissue is at the basis of caste development. The existence of a similar tissue in myrmecophiles and probably also in ants themselves, as indicated by certain guests (*Myrmecophila*, *Oxysoma*, *Attaphila*, *Leptothorax emersoni*) which lick the surfaces of their host ants, suggests a wide and interesting application of Holmgren's theory.

Wasmann [120], replying to Schmitz [111], admits that his views on the relations of *Atemeles* to its hosts have undergone a change within recent years. He repeated Schmitz's experiment with larvæ of *A. emarginatus* and *A. truncicoloides* and found that they were indeed able to bury themselves in the ground and to pupate without the aid of the ants. He believes, however, that *Formica* remains the definitive host of *Atemeles* because it alone, of the two hosts, feeds and cares for the larvæ, and he seeks to harmonize his observations on the *F. rufibarbis* workers, which for two weeks watched the spot in which they had buried *Atemeles* larvæ, with his view that only the forgotten beetle larvæ survive, on the ground that these larvae are often unearthed and killed at a very late date. Under natural conditions the watching of the buried pupæ for long periods probably leads to the destruction of most or all of them by the host ants.

Wasmann [121] publishes a number of observations as a supplement to his many former papers on social parasitism in ants. He introduces the following new terms: "primary pleometrosis," for the cases of alliance between two or more queens of the same species or subspecies in founding a common colony; "secondary pleometrosis," for similar alliances at a later date, *e.g.*, the adoption of daughter queens after fecundation in the parental nest or of queens of the same species but from different colonies, after the marriage flight; "primary allometrosis," for alliance between females of different species or subspecies in forming colonies, and "secondary allometrosis," for the presence of queens of different species or subspecies in a single colony at a later date. The remainder of the article is taken up with an account of experiments on colony formation by young queens of *Formica truncicola*, *sanguinea*, and *rufa*, the supposed temporary parasitism of certain species of *Lasius*, the compound nests of *Leptothorax acervorum* and *muscorum* with species of *Formica* and *Myrmica*, the description of the male of a supposedly new parasitic ant, *Pheidole symbiotica*, found in a colony of *Ph. pallidula*, a supposedly new parasitic *Myrmica* (*M. myrmecophila*), and a criticism and distorted account of Wheeler's observations on colony formation in *Formica rufa*.

Wellman [122] while collecting in West Africa observed a small fly which was laying eggs on living ants (*Cremastogaster* sp.). "The fly rested on her victim, inserted her ovipositor, and then carried the seemingly perplexed and helpless ant into a small deserted spider burrow, where the ant remained until the fly larva had emerged." The fly was at first taken to be a Phorid, but more careful examination proved it to be a new genus and species of Ephydridæ, a family not previously known to contain any species with habits of this description.

Wheeler's book [123] on the structure, development and behavior of ants has been already reviewed in a previous number of this journal (Vol. I, No. 1, p. 73).

Woodworth's paper [124] contains a partial list of the ants of California and a general account of the life history of the Argentine ant (*Iridomyrmex humilis*), which has been recently introduced into California and seems to be slowly spreading over the state, occasioning much annoyance in dwellings and driving out the native ants. According to Woodworth the males and females of this ant, though both winged, do not have a nuptial flight. The females must therefore be fecundated by the males in the parental nest (adelphogamy?), but the author fails to tell us whether new colonies are formed by single females or by females accompanied by detachments of workers from the parental colony. It seems certain, however, from his observations that the species spreads slowly, probably not more than an eighth of a mile a year except when transported by man. "There are many cases where the ant has not crossed the road during the two years it has been under observation."

LITERATURE FOR 1910 ON THE BEHAVIOR OF VERTEBRATES *

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VISION

Fish. In his paper, published in 1909, on light and color-vision in fishes, Hess† maintained that all the results of his experiments were in harmony with the assumption that the fishes under observation were totally color-blind. He admitted that the brightness-distribution in the spectrum is different from that of the human eye. Victor Bauer[125] has obtained certain results upon several different species of fish, which apparently are not in accord with the above conclusions of Hess. Young *Charax* were allowed to live for several days in a long, slender 'phototactic trough.' The trough was blackened upon the inner surface, with the exception of one end. This end admitted the stimulus light. Either one or two ray filters could be set up in front of this end, or any given region of the spectrum could be projected upon it. Diffuse white light was admitted from above in all experiments conducted in the dark room. The introduction of this diffuse light was necessitated by the fact that the fish were restless if the stimulus lights alone were used. Bauer tells us nothing about the intensity of this light. It has rather important bearings upon his conclusions.

Fish with *light adapted eyes*, when tested in the phototactic trough, showed no tendency to collect at the lighter of the two ends. *They were neither negatively nor positively phototactic*, and swam from the light end to the dark end and *vice versa* in a calm and restful manner. If suddenly frightened by a shadow, they attempted to hide themselves by pressing closely to the angles and edges of the glass vessel and remaining there for a time. If one brought a white paper to the unblackened end of the trough, in which the fish had dwelt for a long time, they would swim up to it and press themselves against the glass surface. By degrees they accustomed themselves to the new condition, and swam now here, now there. The reviewer does not know whether Bauer means here to say that the fish became positively phototactic when the paper was introduced, or whether the impulse to press against the bright end was due to what is designated "curiosity" in the higher animals. All through the paper he uses positive and negative phototaxis very loosely. The same phenomenon mentioned above, namely, indifference to photic stimuli, was exhibited by these animals in white light of all intensities except that of bright sunlight or of a very bright artificial light. When light of high intensity was admitted, the fish behaved as if frightened, and swam quickly to the darkened end. When monochromatic light, either from filters or from the spectrum, was allowed to impinge on the unblackened end of the trough, the behavior of the animals remained unchanged, until the orange region was reached. That is, they were indifferent to all regions up to orange. The moment, however, orange was admitted, a sudden change in behavior occurred. The animals were found to be strongly negative to orange and red. The point where the "*Rotscheu*" began was at 620-630 μμ (once at 610 μμ). The "red-shyness" was apparent when two colored filters were used, half the undarkened end of the trough admitting red light, the other half blue light. The animals in the blue light turned the head toward the light and swam into it. Those on the red side turned the head from the light and sought to avoid it by making trial movements and swimming to the other end.

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* I have been greatly assisted in the preparation of this review by Mr. H. M. Johnson, Fellow in Psychology, Johns Hopkins University.

† C. Hess, Untersuchungen über den Lichtsinn bei Fischen. Arch. f. Augenheilk. Bd. 64, Ergänzungsheft, S. 1-38, 1909.

The behavior to red is completely changed by thirty minutes' *adaptation to darkness.* The fish are no longer "*rotscheu*," but behave toward all monochromatic rays exactly as they do to weak mixed light. "Die Fische schwimmen dann (bei entsprechenden herabgesetzer Gesamtintensität) nicht nur auf Blau, Grün und Hellgelb zu, sondern auch auf Dunkelgelb und Rot." One gets the impression from these statements that the red, after the animal is dark-adapted, loses its disturbing color-value, and possesses only a white-value.

C. Hess [135], in a caustic reply to this work of Bauer, points out that he himself has shown that in certain of the forms experimented upon by Bauer, the red has very little stimulating effect; and hence, as I understand him, he would maintain that Bauer's results are due to the fact that the *light-adapted* animals react to red as they would to darkness; *i. e.*, they swim about only in those areas which appear light to them. On the other hand, when the fish are dark-adapted the red becomes supra-liminal and they react to it as to the other rays.

Bauer thinks that he was able to demonstrate the Purkinje phenomenon in three of the forms studied, but from his contradictory statements and from the arrangement of the apparatus it is extremely questionable whether the reactions were due to the presence of the Purkinje phenomenon. He concludes his paper with the rather astonishing statement that monochromatic light possesses both a color value and a brightness value for the light-adapted fish, but that the dark-adapted fish behave throughout as Hess maintains; that is, as though they were color-blind.

Reptiles and Amphibians. C. Hess[136], in a striking series of carefully conducted experiments, shows quite conclusively that the turtle, although its eyes are totally unsupplied with rods, and hence lacking in visual purple, nevertheless possesses the power to adapt itself to darkness to a very high degree. His method for proving this was a very simple one. The light-adapted animal was carried quickly into a dark-room and placed upon a table covered with dead black cloth, with its back to the apparatus admitting graded white light. This apparatus consisted of an electric light contained in a light-tight metal case. This case was supplied at one end with an iris diaphragm working over a ground glass disk. Immediately upon entrance into the dark-room the turtles were presented with a piece of meat (for control tests a small wad of cotton wool was used). The animals were guided in their responses by optical stimuli, Hess tells us, and would, since they were kept quite hungry, snap at the meat the moment it became visible. If, immediately after entering the dark-room, the diaphragm admitted sufficient light, the animals would snap at the food. If the opening were too narrow, the animals refused to strike at the food. The diaphragm was accordingly quickly opened to the point where they would snap. This reading was then taken;

time was allowed for adaptation, and the animal was again tested and the diaphragm again adjusted until the animal would snap at the food. Several determinations of this kind enabled the author to trace the whole course of adaptation to darkness.

The range of adaptive increase in sensitivity in the turtle is considerable. For example, it is so great that a dark-adapted animal can see a piece of moving meat under such conditions of illumination that it is invisible to the bright-adapted human eye. Hess finds that the whole course of adaptation is almost identical with that of the human eye when the latter is covered by a suitable orange-colored glass. The reviewer was not able to find in the article a careful description of the orange-colored glass used.

Hess made tests upon the limits of the spectrum and the brightness distribution in the spectrum, and traced the course of adaptation to colored light by a new method. An arc spectrum 20–40 cm. long, and 5–10 cm. high, was projected horizontally upon a dead-black surface. The turtles were placed upon a table with their backs to the window in the dark-room which admitted the spectrum. Food (white fish-meat, cooked rice, and in most cases, wads of cotton wool), suspended from a dead black wire, was dangled in the light in front of the animals. The food could easily be changed from one region of the spectrum to another. By moving the food over into the infra-red it was quickly determined that the width of the animal's spectrum at the red end was almost exactly the same as that of the normal human eye. Further tests on the violet end show that the reptiles have a very much shorter range there even than the hen. His final conclusion is that both hen and turtles see colors as we do, if we cover the eyes with a suitable red-yellow glass. There is this difference between hen and turtle, however: The human eye must be covered with a bright red-yellow glass which admits some of the green and blue-green wave-lengths, if it is to see the world of colors seen by the hen. It must be covered with a dark glass lying somewhat further along in the red region than the one just described for the hen, and it must restrain the short wave-lengths—*i. e.*, admitting those from the yellow only, if it is to view colors as seen by the turtle. I give these general statements because all of Hess's experimental results seem to show such a relation between human vision and reptilian vision.

Hess believes, from a histological examination of the eyes of both the hen and the turtle, that the reason for the narrowing of the spectrum at the short end is to be found solely in the physical fact that the recipient retinal elements in the one case are placed behind a film composed of red and yellow oil particles (turtles), and in the other, behind one composed of yellow and green particles (hen).

His work upon amphibians is merely summarized. He found *Diemictylus viridescens*, *Bufo vulgaris* and *Xenophus Mülleri* most suitable subjects. All three forms possess retinae liberally supplied with rods. The course of adaptation to white light in the salamander, *Diemictylus viridescens*, was almost exactly identical with that in the human eye. There was no narrowing of the spectrum at the short end, as is the case in reptiles and birds. There is no shortening in the red. They are able to see the food in the blue-green and in the red region as long as can the human eye in a similar state of adaptation.

The paper has important bearing upon theories of color vision. We have a clear proof of the functioning of a light-adaptation mechanism for both mixed and monochromatic light in a retina which is totally unsupplied with rods and hence with visual purple.

Pearse [138], in a closely articulated paper, too extended for review, gives in addition to a good historical survey of the work of other investigators, an account of several experiments upon light and heat responses of different amphibians. After giving a long list of the forms positively phototropic, he states among his conclusions that most of the species mentioned in the list gave normal photic responses after removal of the eyes and that the responses in these eyeless animals are due to the fact that the skin functions as a photoreceptor. Blue light was most effective in the production of the tropic responses in normal animals. But when eyeless individuals were tested with the same colored lights the rays toward the blue end showed no such potency as compared with those nearer the opposite end. He concludes that while both the skin and the eyes are sensitive to the whole range of the visible spectrum, color sensitiveness is present only in the latter. Spinal amphibians gave no photic responses, but such responses were obtained in animals in which the brain anterior to the metencephalon had been excised.

Mammals. Shepherd[141] made an interesting series of tests upon the Rhesus monkey. The animal had to choose between bits of food (cubes of bread or rice) differing in brightness or in color tone. The colored food-cubes were soaked in color-dyes. Punishment for wrong choice was effected by soaking the bit of food which should have been avoided in a fairly strong quinine solution. The remarkable thing about the results of the experiment is the fact that the associations were formed very rapidly. The selection of a very few of the quinine-soaked cubes served to fix the correct response. If the animals were really making the discrimination upon the basis of visual stimulation arising from the differences of intensity or color-tone, and not through smell, the unintentional signs given by the experimenter or other extraneous cues, the rapidity of the rise of the discrimination, when viewed in the light of similar tests upon other animals, is little short of marvelous.

The author maintains valiantly that his tests show keen brightness discrimination, and ready discrimination of colors on the basis of hue. But the method adopted was in so many ways inadequate to solve so difficult a problem that detailed criticism and discussion of the results must await a repetition of the experiments by other means.

Waugh[146] gives a belated report of his study on vision in the mouse. Both albino and black and white mice were used. The discrimination of light intensity was tested in two or three ways, under both direct and indirect illumination. The mouse distinguished differences in grays and in brightness with considerable accuracy. Red and blue objects which appear of equal intensity to the human eye are discriminated between by the mice. Red and yellow are preferred to blue and green. According to Waugh, albino mice do not show any discrimination between red and white lights. Black mice distinguish between very bright red and white of low intensity with greater difficulty than colors which are to the human eye of equal brightness. There is no discrimination between green and blue light. The mice have a poorly developed perception of form. The distance of objects is perceived within a range of 15 cm. The mice fail to improve in estimating the depth of objects. The author makes no mention of the influence of the vibrissae in the last two tests, yet he speaks of the marked "stereotactic" instinct. One of the most obvious things to do in making such tests upon an animal which uses its vibrissae to such an extent as the mouse is to keep them clipped from birth. Not until then can one force the animal to show clearly what powers of accommodation and convergence it has. The author's findings on the anatomical side are in agreement with those obtained several years ago by Slonaker. The retinae of the mice are lacking largely in cones. There is no fovea. The range of vision is wide, and there is the possibility of a small binocular field.

AUDITION

Fish.—Bernoulli [126] gives a clear and succinct account of the work done on hearing in fishes. His own results support the negative conclusions of Kreidl and of Körner, and are against the positive conclusions of Zenneck and of Parker. He repeated the experiments of Zenneck, but worked more carefully than the latter. A bell with C_3 for its fundamental, with a basal diameter of 94 mm. and height of 62 mm., was fastened to a very firm support with the dome immersed in water ("mit der Kuppel nach unten eingetauscht"). The bell was electromagnetically actuated. The key for closing the circuit was placed several meters away, behind a stone wall. The fish ("Forellen," also eels and individuals belonging to Zander, *Lucio perca sandra*, cuv.) were tested in an open stream, and hence under natural conditions of life. He was not able to get the slightest reactions under these conditions. "In keinem einzigen Fall haben die Forellen (*Salmo fario* L.) irgendwie auf das Läuten der Glocke reagiert."

Incidental observations showed that the fish (*Salmo fario* L. and *Thymallus vulgaris* Nilos) were totally insensitive to shrill pipes, the sound waves from which were conducted to the water by the aid of a metal tube 4 m. long and 30 mm. in diameter. Other observations showed that the fish (Zander?) were totally insensitive to pistol shots fired at a distance of 2 km. His final conclusion is that the fish do not hear, but respond tactually or visually, when at all, to the mechanical motion in the water.

Zeliony [150] reports some observations made on a single kitten, which was with some difficulty taught to come from another room to be fed at the sounding of the C of a set of tuning pipes, and to inhibit the reaction to other tones. Detailed description of the learning process is not given, nor were any control tests introduced, "because before the investigation was completed, the cat had disappeared." This contribution hardly lessens the need of accurately controlled tests of auditory discrimination. The author advocates the superiority of the saliva-reflex method of Pawlow over the method of muscular reaction in tests of audition.

Swift,[142] not satisfied with the conclusions of Kalischer and Rothmann as to the "psychical" character of the reactions of their dogs, trained two dogs, after the method of Kalischer, to discriminate between c′ (Fresston) and e″ (Gegenton), using a trumpet on which to sound them. Fourteen days sufficed to perfect the reactions. After a month of rest the first dog's left temporal lobe was extirpated. This produced right hemianopia but did not affect the reactions to the two tones in the tests which were given three days later. Ten days later the right temporal lobe was also extirpated. This rendered the animal's blindness nearly total, and also produced left hemiplegia. Discrimination of the tones, however, was not affected. The second dog was similarly operated upon, but both temporal lobes were extirpated at once. She, too, was able to discriminate the tones as before. Swift considers that the center in question must therefore lie in some other portion of the cortex. He also argues that the reactions are not reflex as Kalischer holds, but involve an intellectual process, and a well developed "ability to think." However much we may value this opinion of the author, his anatomical findings support the conclusions of Kalischer.

Shepherd [141] reports that he taught Rhesus monkeys to discriminate between two noises differing mainly in intensity. In order to produce the two noises, a slat 18 inches long was fastened to the top of a box. By placing a stick vertically under the slat and suddenly withdrawing it, a fairly loud noise was produced. The intensity could be varied by varying the length of the sticks. Sticks of 3 inches and 5 inches in length were actually used. The animals were kept near by in a cage. They reacted to the stronger of the two noises by climbing upon a platform arranged inside the cage. The apparatus producing the noises was out of sight. About 80 trials were required for monkey 4 to complete the discrimination. Monkey 6 formed the habit in 110 trials, whereas monkey 5 failed to acquire the habit in the time allotted for the experiment.

Shepherd's experiments upon pitch discrimination were quite crude. The German mouth harp was used for producing the tones. At the sound of the higher tone, A_3 (?), the monkey was expected to respond by climbing to the platform used in the intensity-discrimination test. When A_1 (?), two octaves lower, was sounded, the monkey was expected to refrain from climbing. It was not fed when the lower tone was given. Monkey 4 learned to respond correctly in three days (60 trials); monkey 6, in four days (80 trials), while monkey 5 did not learn to make the response within the time limits of the experiment.

OLFACTION

Fish. Parker,[137] experimenting on the feeding movements of the common fresh water catfish, finds that the animals remain in a state of considerable excitement after the last morsel of food has been eaten. During the period of excitement the fish swim about in the lower part of the aquarium in various directions, frequently sweeping the bottom with their barblets. In actual feeding they seldom seize food until their barblets have come in contact with it. Since they show excitement at a distance, it would seem that they scent their food. That the olfactory apparatus really functions follows from the operative experiments of Parker. In one set of five animals he removed the barblets, thus partially eliminating the sense of taste. In another set of five he sectioned the olfactory tract and threw the peripheral mechanism out of function. When tested for one hour in a tank which contained chopped worms placed in a cheesecloth bag, the fish with barblets removed seized the food 34 times. The anosmic animals, on the contrary, did not seize it at all. A cheesecloth bag without the worms was then substituted: no fish of either of the two groups seized it. Repeated tests of this kind furnished Parker evidence for affirming that the catfish, "though a water inhabiting animal, possesses an olfactory organ that is as much an organ of smell as is the olfactory organ of the air inhabiting vertebrates."

TASTE

Amphibia. Cole [127] suspended fresh, brainless frogs from a hook on lever device and dipped their hind feet into given solutions of chlorides of ammonium, potassium, sodium, and lithium. After a variable time the frogs withdrew the feet from the solution. The time of the reaction (from the moment of immersion to the moment of withdrawal) was taken with a stop-watch in seconds and fifths of seconds. The reaction times of the frogs to 3m., 2m., 1m., and m/2 solutions of these chlorides gave grounds for "distributing these salts into two groups—ammonium and potassium; sodium and lithium, an arrangement already indicated by their degree of concentration." The most rapid reaction occurred with the chlorides of greatest dissociation. It is suggested that the total reaction time includes two factors: diffusion time and summation time.

On the question of the receptors involved in the reaction Cole suggests without sufficient evidence that "the comparisons with the tastes of chlorides of these metals and the results of applying cocaine, suggest that nerves of a general chemical sense rather than pain nerves are affected by the chlorides."

EXPERIMENTAL AND OBSERVATIONAL STUDY OF INSTINCTS

Mammals. Yerkes and Bloomfield [149] have made an interesting set of observations upon two litters of kittens, to test the definiteness of their instincts for catching and killing mice. It will be remembered that C. S. Berry, a few years ago, reported from his observations upon a litter of Manx cats that "cats are credited with more instincts than they really possess. It is commonly reported that they have an instinctive liking for mice, and that mice have an instinctive fear of cats. It is supposed that the odor of a mouse will arouse a cat, and that the odor of a cat will frighten a mouse. My experiments tend to show that this belief is not in harmony with the facts. When cats over five months old were taken into the room where mice were kept they did not show the least sign of excitement. A cat would even allow a mouse to perch upon its back without attempting to injure it. Nor did the mice show any fear of the cats. I have seen a mouse smell of the nose of a cat without showing any signs of fear." Berry concludes finally that it is through imitation that the average cat learns to kill and eat mice.

Yerkes and Bloomfield have reached wholly different conclusions from their experiments. They made their tests upon two litters of common cats. Their animals were carefully fed upon fresh milk, beef, usually cooked, and fish. They were housed in a room free from mice. In the first week of life the kittens showed no special interest in mice. Shortly after they gained their sight (12 days of age) they were again tested, but the presence of the mice did not elicit the instinctive response sought for. When slightly over four weeks of age three of the first litter of four failed to exhibit the instinct, as before. One of the kittens, however, now exhibited a type of behavior quite in contrast with that of the other three. "She noticed the mouse soon after she had been placed in the cage, as it moved near her, and quickly seized it, growling the while. The mouse escaped and the kitten gave chase, but failed to recapture it before it had climbed to the top of the cage."

Five days later the kittens were again tested. Nos. 1, 2, and 3 acted as before; No. 4, as in the above test, made efforts to catch the mouse. Two days later the test was repeated. Kittens 1, 2 and 3 showed a marked interest in the mice, but behaved as in the other tests. No. 4 exhibited almost a complete repertoire of movements used by adult cats in catching and killing mice. The mouse was pursued, caught, worried, killed, and partially eaten. The tests were continued upon the remainder of kittens belonging to the same group as No. 4, and upon four kittens belonging to a second litter. All the animals tested, at slightly varying ages, exhibited the characteristic instinctive behavior of No. 4. The instinct to kill commonly appears at about the end of the second month. It may appear as early as the end of the first month. Since Berry worked with kittens five months old, his negative results were probably due to the fact that the instinct had waned through disuse.

A. Franken,[128] in an exceedingly long and diffuse paper, reports some tests on the intelligence of the dog, which are much like those made by Hobhouse several years ago. It is singular that Hobhouse is not quoted as a reference. Thorndike and Lloyd Morgan are the only English references given. Some of the principal statements made by the author are as follows: The characteristic instinctive movements of the dog are concerned directly with the goal (obtaining of food). His method of attack is a random one ("Probiermethode"). The problem is not learned by one successful solution, but by many repetitions. During the learning process involuntary attention is withdrawn more and more from the goal, and is directed toward the method of arriving at the goal. Changes in the arrangement of the apparatus call out new trial movements. Check experiments ("Vexierversuche") following too closely upon one another tend to break down the reaction.

The author makes a distinction between sensory and motor reactions which is not clear to the reviewer. He says that motor reactions predominate, and that sensory reactions are called out only by some external demand ("*äussere Nötigung*"). If the external demands are continuous and compelling, the dog can accustom himself to the sensory reaction. I presume this statement refers to the fact that the dog can learn to discriminate between the different cords, strings, etc., used in the experiments.

His conclusions concerning the general levels of intelligence of the dog are not far removed from those of Thorndike. The dog shows no evidence of reflection. There was little evidence even of sensory thought ("Nur in einigen wenigen Versuchen äussert es sinnliches Denken, das allerdings bis zu einem gewissen Grade einer Erziehung fähig ist.")*

Birds. Herrick,[133] in an admirable study of the young and adult cuckoo, largely increases our knowledge of the first appearance, the development, and method of functioning of instincts in birds. The paper shows quite clearly how much valuable work can be done by a study of animals in their natural environment. The instinctive activity of the birds studied is too complex and detailed to be reviewed fully. The author's especial interest centers about the peculiar instinct in the adult cuckoo, to lay its eggs in the nests of other birds. Herrick would find the origin of "parasitism" in many of the old world cuckoos and in the American cow-bird, in the disturbance of the cyclical reproductive instincts; in particular, that of the attunement of egg-laying to nest-building. This maladjustment shows itself in the laying of the eggs before the nest is ready to receive them, and in laying them at very irregular intervals. For example, the interval in *Cuculus canorus* is sometimes six to seven days. This makes brooding almost impossible. Even the American cuckoo, which builds its own nest, broods its own eggs and cares for its own young, shows a strong tendency to lay eggs at irregular intervals. Brooding is made possible, however, in the American cuckoo, by the presence of a compensatory instinct in the young, which, after a short stay in the nest, crawl out in the order in which they were hatched, and pass through a climbing stage. The reason for the disturbance in the reproductive cycle cannot be stated, but it is probable that it is independent of food-habits.

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* It is somewhat surprising that an important psychological journal should have been willing to devote more than 100 pages to an article which judged by our American standards does not rise above the level of the ordinary student's 'note-book.'

Herrick's three other papers [134] form the best discussion we have at the present time of instinctive action in birds. This valuable observational material ought to stimulate further experimental work of the type begun by Breed in the Harvard Laboratory.

ORIENTATION

Fish. Greene [131] by means of an aluminum button attached to the caudal fin, was able permanently to mark a number of salmon entering the mouth of the Columbia River. By this means the author hoped to study the length of time spent by the fish in the tidewater regions after entering the mouth of the river, and to determine the speed of individuals after the tidal area had been passed. The success of the experiment depended upon the fact that the commercial fisheries stationed along the river would recapture the marked individuals, and return the tag to the author. The aluminum button corrodes in salt water. The length of time spent in the tidal regions could thus be approximately gauged by the amount of corrosion showing on the button. Fifty-nine fish were marked, and 17 retaken. The conclusion arrived at by the author is that from 30 to 40 days were consumed by the fish in crossing the tidal area (a much longer time than was formerly supposed); and that once the fish had passed the tidal area, they made the journey up the river at an average speed of not less than seven and one-half miles a day.

Victor Franz [129] maintains that fish have an extraordinarily well developed sensitivity to differences in hydrographic conditions. Currents are detected by means of the lateral line organs; temperature, through the warm and cold corpuscles in the skin; salinity, through the sense of taste; depth through pressure and vision. The paper is a resumé and not a report of experiments. His chief argument is that the spawning migration is not actuated by any sexual instinct, but is an adaptive change which has as its end the obtaining of optimal developmental conditions for the young. It is conditioned solely by hydrographic phenomena.

Thauziés [143] gives the record in detail of the homing pigeons released by him at Geneva when the Sixth International Congress was in session. Birds belonging to the three cities, Versailles, Guéret, and Gannat were used. None of them had flown from Geneva previously. The birds from Versailles had been trained toward Brest, those of Guéret towards Amsterdam, and those from Gannat, towards Macon.

Versailles: 24 birds were released August 6: two returned the same day at about 5:45 P. M.; nine returned August 7 at different hours; by the 10th of August all the birds had returned.

Guéret: 38 released at 7:15 A. M., August 6; two returned the same day a little after noon. The rest returned on the following morning.

Gannat: eight pigeons were released at 7:20 A. M., August 6. None returned the first day. On the 7th of August three returned in the morning; one on the 8th, and one each on the 9th, 11th and 12th. One had failed to return by the 17th.

Hachet-Souplet [132] reports a set of experiments made upon pigeons reared in movable cotes. The pigeons were taken from the wagon at a point A and placed in a basket. The outside appearance of the wagon was of course familiar to the birds. The "traveling cote" was then driven to a point B, 5 km. from A. The pigeons were released. They quickly found the cote at B. The experiment was then repeated with the distance between the two points increased to 10 km. Care was always taken to place the wagon, covered with a large drapery, in an open place. The birds invariably found it at this distance. The moment 10 km. is exceeded, a decrease in the number of returns is noticed. No returns were obtained from distances greater than 12 km.

Now, by proceeding in another way, the birds may be made to return to the wagon from much greater distances. On leaving the point A, two birds are attached to the outside of each wagon by a cord in such a way that as the wagon travels they can view the surrounding country. The string permits the bird to rise to a height of 35 meters. On arrival at the point B, the bird is allowed a few moments in which to "take note" of the present surroundings of the cote. It is then put into a covered basket, sent back to the point A, and released. On the first trial a successful return of eight birds from a distance of 100 km. was obtained. The ten pigeons which had been transported inside the wagon failed to return when given this test. The author tells us that these experiments have been repeated many times.

Watson [145] continued his tests on the homing sense of the noddy and sooty terns during the season of 1910. The weather was unfavorable for the work. Birds of both species were released in New York harbor, Galveston, and Mobile. All were in poor condition on their arrival at these ports, and none returned to Bird Key. Two out of three noddies released in mid-ocean between Bird Key and Galveston (460 miles due west from Bird Key) returned at the end of three days. These returns are significant by reason of the fact that all possibility of return through the help of visual familiar clues apparently is excluded. One out of a group of four sooties released at night en route to New York, 365 miles northeast from Bird Key, returned at the end of four days, and one other possibly returned after the experimenter left the island.

Cyon's hypothesis of a special nasal sense was tested by closing tightly with asphaltum the outer nasal chambers of two noddies, and releasing them at Key West, 65¼ miles due east of Bird Key. Both birds returned in normal time. The nasal chambers were still tightly closed with the asphaltum when the birds were retaken on their nests the following morning. Out of a group of twelve noddies and twelve sooties released in Key West, all twelve noddies returned, but only ten of the sooties. The time of the return varied from 17½ hours to 11 days.

Thauziés [144] argues for the presence of a magnetic sense in the homing pigeon. He presents no critical experiments which would further such an hypothesis. The only observations seeming to support his case are as follows: On 18 August, 1907, the homing pigeon fanciers of Pir released at Orleans, 320 km. distant, at 6.30 A. M., 99 young pigeons. The day was clear, calm, and hot. Up to the date mentioned, the birds had been satisfactory fliers. The first birds, only eleven in all, arrived at 2.20 P. M. The rest returned the following morning (the trip requires about five hours). Several other societies in the region reported similar irregularities in return. On 22 July, 1906, several young pigeons had been released 65 km, from their cote. These were well trained birds. They would normally require slightly less than one hour to make the trip. On this date the birds first appearing required three hours, and many did not return at all.

Examination of the meteorological conditions of the two days showed a violent magnetic storm on each, and great heat. Thauziés maintains that the heat does not affect the birds. He attributes their abnormal behavior to a disturbance of their magnetic sensibility.

IMITATION.

Mammals. Witmer [147] cites the act of a monkey (*M. cynomolgus*) in opening a door of a greenhouse as one involving intelligent imitation. According to the author, the monkey did not have to learn the act by trial and error, since she opened it at the first attempt. This monkey learned also to open the door of a cage, as well as the door leading into another room, the knob of which she could reach through the bars of the cage. "This door was partly of glass, and through it she could look into the adjoining room. On one occasion I saw her observe intently some people in this room who were about to come into the room containing her cage. She reached through the bars of the cage, turned the knob of the door, pushed the door wide open, and sat waiting on her haunches with expectant gaze. There could be no doubt that she had conceived in her mind the entrance into the room of the persons whom she saw in the adjoining room, and it looked as though she had opened the door for the purpose of allowing them to enter." Witmer cites other observations of the same type.

This paper, as well as the one by the same author on "Peter," [148] is a return to the worst type of anecdotalism. It is sincerely hoped by the reviewer that the work appearing on animal psychology from this laboratory, which apparently yields such prodigious and interesting results with such a slight expenditure of energy, will not be considered seriously until there is shown some tendency on the experimenters' part to control their experiments, and to consider in some measure the work of other investigators.

Shepherd [141] repeats on the Rhesus monkey two of the imitation tests made by Hobhouse and by Watson. Pushing food from a glass tube was the first test given. The animals failed to show any signs of imitating the movement of the experimenter. The simple act of pulling in food with a T-rake was the next tried. Six of the animals failed in it. Two of the monkeys seemed after a few days to give some evidence of imitation. They learned to imitate the experimenter in pushing out the rake, perfectly, but the pulling in of the food with the rake remained imperfect to the last. A third and new type of experiment was next tried. A banana was suspended out of reach of the animal. By pushing a sliding pole arranged to work in a horizontal plane two feet six inches from the floor, to the right or to the left until it lay in the same vertical plane as the banana, and then mounting upon it, the animal could reach the food. The monkey longest tested in this experiment slowly improved, apparently by virtue of the tuition afforded him by the operator.

Birds. The work of Porter [139] is concerned with learning in several species of birds not hitherto extensively studied, *e. g.*, the junco, numerous varieties of sparrows, Baltimore orioles, blue jays, bluebirds, and crows. The author's chief interest in the work centers around the problem of imitation. His method of testing imitation differs from the methods of other investigators, in that the "imitator" was never confined. Porter allowed several of the birds to work together, displacing each other at the task whenever opportunity afforded. He states that this method introduces such motives as rivalry, competition, struggle, fear, "new caution," interest and attention. The writer's description of his method is unclear. His preliminary work gave him a new criterion of imitation, which I quote in full: "Early in the present work the writer began to make use of the criterion of the presence of imitation which may be stated somewhat as follows: Bird No. 1 is induced to open a box, which may be done in one of several different ways. Bird No. 2, by the means indicated above, is allowed to supplant No. 1. The effect of this different method of opening on the behavior of No. 1 is closely observed and recorded. The behavior of No. 2 will rarely be identical repetition. We may be fairly certain, then, that No. 1 will have furnished to him by No. 2 or *vice versa*, an example or act to imitate."

Porter states that he found satisfactory evidence of the presence of imitation in most of the birds tested except the blue jays. There was some evidence that members of the same species imitate each other more closely than members of different species.

HABIT FORMATION

Mammals. Glaser[130] succeeded in obtaining the rapid formation of habits in the white rat by a rather ingenious method. A zinc tank about two feet square and six inches deep was covered with coarse wire netting and filled with water. A circular opening was made in the center of the wire gauze and fitted with a cylindrical shoot. Each of the four corners of the cover was supplied with a small opening covered with a hinged door. Any one of these openings, at will, could be made the true exit from the maze. The time record of the escape from the labyrinth was taken and a plot made of the animal's path. In addition to the data obtained upon habit formation under these novel conditions interesting comparisons are made between the adults and the young with respect to the rapidity of habit formation. The facts obtained on the rat's use of its senses in the maze support in the main the work of other investigators.

LITERATURE ON ANIMAL PSYCHOLOGY PUBLISHED IN FRANCE DURING THE YEAR 1910

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The French literature for 1910 is not extensive, and deals almost wholly with invertebrates. There is a very marked tendency to study the reactions of animals from the chemical point of view. The hypothesis that sensibility is a function of the rate of chemical reactions is in my opinion likely to prove very fertile.

In the series of publications, numbers [28, 29, 30, 31, 32,] in the bibliography, I have applied the concepts of physical chemistry to the study of the sensibility of the lower animals. I have recognized that such sensibility varies within rather wide limits; thus the Veritillum (*Veritillum cynomorium*) is at times absolutely insensible to light and to mechanical stimuli, while at other times its sensibility is very great; sometimes merely touching the tentacle of one polyp makes the whole colony retract. I observed lessened sensibility especially under the three following conditions: prolonged illumination; repeated stimulation; continued activity. Light, when it has acted *a certain length of time* on the organism, is a desensibilisator. An actinian exposed to strong illumination finally becomes insensitive to light and expands: the process is more rapid the stronger the light and the higher the temperature. Consequently the reactions of many beach-dwelling animals towards evening differ from the morning reactions, under the same conditions of illumination and surroundings. On the other hand planarians, living under the stones in brooks or streams, quickly lose sensibility even to diffuse light: it is possible to note the rise of threshold from hour to hour. The whole process is what would happen if light destroyed a certain active substance in the organism.

In general, mechanical shocks heighten sensibility; but if they are repeated a certain number of times the opposite effect is finally observed. Loss of sensibility under these conditions occurs sooner, the longer the exposure of the organism to light; in the morning shocks continue to heighten sensibility for a long time; in the evening they quickly produce a loss of sensibility. Under the influence of shocks, we should have exhaustion of certain active substances, but the organism is more richly supplied with these substances in the morning than in the evening.

I studied chemical, physical, and mechanical sensibilisators, but more particularly the last. I recognized among other points that one can modify the sensibility of an organism merely by changing its orientation to gravity: a mollusc (Littorina) with its head downward has less visual sensibility than when it is moving with head upward. This would correspond to an altered distribution of active substances in the cells of the retina. I also observed an effect of increased sensibility as a result of increased surface of the body in animals whose bodies swell, for instance the Veritillum; and under the influence of increased pressure or of weights carried by the animal: ants with a load are much more sensitive to light than those which carry nothing.

Finally, I pointed out that all these variations in sensibility may be taken account of in the study of tropisms.

Matisse [54] worked with the following species of animals: *Sagartia parasitica*, *Asterias rubens*, *Nereilepas furcata*, *Arenicola piscatorum*, *Sipunculus nudus*, *Haminea navicula*, *Cardium edule*, *Pectunculus glycimeris*, *Sepia officinalis*, *Eupagurus bernhardus*.

He took proper account in his experiments of the oscillations in sensibility and motor activity at different times. Cold more or less rapidly and completely suspends the sensibility and motor activity of organisms: between 10° and 2° C. most of the animals studied became insensible and inert. The functions of nutritive life (respiration and circulation), however, were continued with sufficient intensity. In the cuttlefish the case is different: as the life of response diminishes the functions of vegetative life weaken; death occurred at 7° C. by respiratory paralysis accompanying locomotor paralysis. The action of cold is in general reversible; the same is not true of the action of high temperatures, which often produce the same effects as cold. However, differences may be observed: at 34° C., Sagartia dies in a few hours, in a state of contraction; at 2°, the anemone expands, loses sensibility, but remains alive. All these facts are easily explained by invoking the conception of speed of chemical reaction.

Rose [60] has studied tropisms to light and heat and the corresponding differential sensibility in Daphnia. Among other results he verified the observation of Loeb that weak (n/500) mineral acids are sensibilisators. He verified also a law which I have pointed out: any sudden variation in the light produces a vertical displacement in the animals: if the intensity is suddenly increased they sink, if it is diminished they rise. He recognized that Weber's Law would be applicable in this connection, and he has extended to warmth the results which have been found for light. The notion of differential sensibility based on certain laws has shown itself fertile here.

Drzewina [38] has studied the reactions to light of *Clibanarius misanthropus* Risso. At Arcachon, on the Atlantic, she noted a curious parallelism between the fortnightly movements of the tide and the periodicity of variations in the sign of phototropism. But at Banyuls, on the Mediterranean, she always found marked positive phototropism, a fact which is not surprising in view of the different ethological conditions. However, starting with the hypothesis that heliotropic sensibility is a function of the speed of chemical reactions, D. succeeded in modifying the sign of the reactions to light. If the water in the vessels is daily changed, the phototropism remains positive, but it becomes negative in unrenewed water. The addition of sea salt (1 to 100) raises the sensibility to light and neutralises the influence of impure water. With carbonic acid (10 parts of Seltzer water to 100) change in the sign of the phototropism results at once. Individuals long exposed to light and those subjected to prolonged shocks finally move towards the shade.

Further, Drzewina [37] has made an elegant application of the associative method to the study of sensations in these crabs. She put naked hermit crabs near shells hermetically closed with cork; the animals at once fastened upon them, trying to tear off the cork. Their efforts were in vain, and in time they appeared more and more indifferent to the shells; six or eight days after the beginning of the experiment, when they encountered them, they continued on their course, or even pushed the shells away. Now if at this point shells were introduced similarly stopped with cork but of a different shape, the behavior of the animals changed at once. As soon as a crab encountered a shell he carried it off, and for five or ten minutes persistently explored it in all directions and tried to pull off the cork. This fact proves not only that new associations can be formed in these crabs, and that consequently they are susceptible of training, but also that they are capable of apprehending form differences by means of tactile sensations.

Two important memoirs relating to the experimental analysis of instincts, by Faurot and by Cornetz, have appeared.

Faurot [41] first studies the adaptive conformation of the hermit crab and the deformity and growth of *Adamsia palliata* in symbiosis with *Eupagurus Prideauxi.* The development of the actinian forms in a certain sense part of that of the crab. The association of *Pagurus striatus* and *Sagartia parasitica* presents quite different features; it does not begin until the two organisms have almost reached their normal growth, and it is always possible for them to live separated from each other. F. investigates the mode of formation of the two sorts of association; symbiosis and mutualism. He brought together naked *Eupagurus Prideauxi*, others lodged in shells furnished with Adamsias, empty shells with Adamsias on them, and Adamsias either isolated from their shells or adherent to some support. In general the crabs recognized the Adamsias by means of their tactile sensibility, which is extraordinarily developed; they immediately carried off an *Adamsia palliata*, but not *Sagartia parasitica*, *Heliactis bellis*, or *Corynactis viridis.* Crabs provided with Adamsias, put near naked shells, did not exchange their shelter for the latter. If they were despoiled of their associates, they fell upon a naked shell with as much eagerness as if it had been an Adamsia. If, however, the separation were of less recent date, the attracting reaction produced by contact with a naked shell was much weaker. In the search for shells and actinians sight plays a certain rôle; the visual field would be bounded by a regular circle whose radius is the length of the antennae plus four to six centimeters.

F. describes a *Pagurus striatus* detaching a *Sagartia parasitica* from the bottom of the aquarium: the claws of the crab grasp the actinian especially in the region near the edges of the pedal disk. This region gradually diminishes in diameter and the disk detaches itself from the support; the tentacles of the actinian then fasten on the shell, then the column bends in such a way that the pedal disk approaches the shell. After this kind of somersault, the actinian fastens itself on the shell occupied by the crab. Six or seven may attach themselves successively upon the same shell.

Cornetz [86, 87] has observed the following species of ants in Algeria: *Messor barbarus* and its variety *sancta*, *Aphaenogaster testaceopilosa*, *Myrmecocystus cataglyphis bicolor*, *Tapinoma erraticum nigerrimum*, *Tetramorium caespitum punicum*, *Pheidole pallidula*. He collected with great care about two hundred paths made by ants travelling alone. The return to the nest seems to be a function of the outward journey; if an ant is captured at the mouth of the nest and carefully transported several meters away, she is unable to return, while the home journey is rapid and easy when the explorer has herself made the outward trip. However, the two paths, outward and homeward, are never superposed; the sequence of movements and attitudes is quite different on the return journey; an ant who crosses her trace left on the outward trip does not stop and does not follow it. The new and important fact brought to light by C. is the faculty possessed by the exploring ant of maintaining her course in a given direction. The insect adopts her direction on leaving the nest and keeps it as well on the return journey as on the outward trip, always resuming it after the path has been interrupted either by her own researches or by the intervention of the observer. The ant suddenly stops, makes a turn, a loop, a double loop, a complicated search in the grass; or perhaps, threatened, she flees in one direction or another, but soon after, she replaces the axis of her body in the direction adopted on leaving the nest, behaving somewhat like a compass. The error in degrees which she makes in thus replacing herself is usually very slight. Ten or twelve such intervals of searching about may intervene, but the course remains governed by the direction taken at starting. On the outward course the road is interrupted, but the same orientation constantly reappears; on the return, it is still preserved. Thus the ant is brought back to a point not far from her nest; to find it, she makes the windings described by Turner. Sometimes the phenomena are a little more complicated; the insect outward bound adopts successively two directions, often at right angles to each other, and on the return retraces them successively in inverse order.

This work of C.'s, as he expresses it, "undermines the theory which attributes the return to the nest to muscular memory." The sequence of movements on the return journey is often quite different from that of the movements performed on the outward course. When there is a change of direction, it cannot be attributed to muscular memory; if, at such a moment, the ant is on a movable support, and the support is turned through a certain angle, the ant, disturbed, after having made various movements, takes the same direction that she would have taken without the interruption. In any case, there are two kinds of muscular memory: memory of a sequence of movements, and memory of the total work accomplished. According to C., the first does not exist in ants, and if we admit the second, it is of a very crude sort, and cannot explain the return to the nest. We have, in fine, memory of one or of several successive directions, which it seems to me cannot be explained except by associative memory acting on the sensations furnished by certain landmarks. We are thus brought back to the conception maintained by the American investigator Turner.

Many observations have been made on the habits of insects and birds. As regards the latter, a certain number of studies are reported in the *Revue francaise d'ornithologie;* the subjects are the maternal instinct, nest-building, and migration. Among the best observers of insects I may cite Ch. Ferton and E. Roubaud.

Ferton [66] among other things describes certain peculiarities of nest-building (closure by partitions of parchment, building a barricade of sand) and gives numerous details regarding the prey of the Hymenoptera. We may note also certain curious observations on the methods used by Pompilidae to paralyze spiders, and on "attention in the return to the nest."

The Synagris are solitary wasps belonging to the family of the Eumenides and living exclusively in Africa. By the study of three species, Roubaud [79, 80] has been able to show instinct evolving from the "once-for all" type of provisioning the nest usual with the Eumenides, towards the continuous supplying of food and daily care of offspring which is found in social wasps.

Thus in a single genus we find the principal stages leading from the primitive instinct of solitary wasps to the far more highly developed instinct of social wasps.

It is to be regretted that the French have almost wholly neglected experimental researches on the higher animals, which have given such fine results in America. The only method used on the higher animals is that of training.

The paper by Hachet-Souplet [9] is a lecture summarizing the ideas already expounded by the author. In particular, H.-S. reports experiments where he accustomed birds to react in a definite way to a definite variation in illumination. He explains what he calls the law of recurrence, one of the laws of sensory association, and accounts by its means for the supposed rational foresight of birds. Intelligence does not come in until there is a possibility of "persuasion" (see also C.r. Acad. Sci., CL, pp. 238 and 735).

Besides these accounts of personal investigations, we have to note a certain number of discussions of the problems of comparative psychology, such as "La genèse des instincts esclavagistes et parasitaires chez les Fourmis," by Piéron [10], "L'orientation lointaine," by Thauziès [20], "L'étude objective des phenomènes cérébraux," by Bohn [2], "Le dressage des animaux," by Drzewina [6], and finally, a book by Piéron [17] on "L'évolution de la mémoire." This book, published in the *Bibliothêque de philosophie scientifique*, comprises two parts, the one dealing with animals and the other with man. In the former, the author after having indicated the relations of the phenomena of inorganic memory, of hysteresis, for example, with those of psychic memory, studies rhythmic persistances (plant rhythms, animal rhythms, organic rhythms), and dwells at length on the discussion of facts and experiments regarding animal memory, which he classes under three heads: adaptive memory, acquisition of habits, sensory memory. These rubrics correspond to the different methods of research on animal memory, such as the study of the modification of reactions under the influence of repeated stimulation, the study of the reproduction of movements, and that of the recognition of images. The author devotes only a few lines to the work of the school of Pawlow, although it is generally considered of great importance for the study of associative memory in the higher vertebrates. He insists on the distinction between motor memory and sensory memory, and considers muscular memory to be involved in the return of insects to the nest. In the second part of the book the author discusses the aspects and limits of human memory, what its disturbances consist in and what its progress may be. He attempts to prove that man is not a creature essentially different from the animals, an opinion which seems to be still quite common in philosophic circles.

A DISCUSSION ON INSTINCT

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At a joint meeting of the Aristotelian Society, the British Psychological Society, and the *Mind* Association, held in London in July, 1910, a symposium was held on the subject of the relations of instinct and intelligence. The papers presented were afterwards published in the *British Journal of Psychology.*

The discussion was opened with a paper by Professor C. S. Myers,[15] in which he took the position that the terms instinct and intelligence refer rather to different aspects of behavior than to different types of behavior. "So far," he said, "as instinctive behavior can be regarded from the standpoint of the individual experience of the organism, it appears, however imperfectly, as intelligent—characterized by finalism. So far as intelligent behavior can be regarded from the standpoint of observing the conduct of other organisms, it appears, however imperfectly, as instinctive—characterized by mechanism. Two assumptions," he continued, "are commonly made with regard to instinct: first, that the organism is unaware of the end to be accomplished, and second, that the behavior is unalterable and perfect from the outset. As regards the first assumption, instinctive action differs from reflex action not only in being accompanied by a feeling of activity, but also by a further accompaniment, that of vague awareness of results. This position of Myers' needs to be made as clear as possible by the full statement of his own words. "To my mind it is certain that, on the occasion of the chick's first peck, or the duckling's first swim, the bird is dimly, of course very dimly, conscious of the way in which it is about to act. I believe this because no organism can ever execute a new movement which does not involve other movements that have been performed previously. A completely new movement is as impossible as a completely new thought. When a chick first attempts to peck, many of the muscles then called into action must have been contracted before. Thus the feeling of activity arising on the occasion of the chick's first peck is not altogether a new one. It is related, as each of our own experiences is related, to past experiences. And the very vague awareness of results which is associated with those previous feelings of activity gives the chick a vague awareness of the result of its first peck before it has actually performed the action. Such awareness is, of course, rudimentary in the extreme. The chick or duckling cannot then—or indeed ever—be aware of the aims of its instincts, as we are aware of them. But it is important to note what rudimentary consciousness of this kind exists, and to realize that it is the embryonic representative of meaning."

The other assumption, that of the perfection of instinct from the outset, Myers disposes of by quoting instances of the variability and imperfection of instinctive behavior. He suggests that the difficulty of enumerating human instincts may rest on the fact that our own actions never seem to us determined by instinct; seen on the subjective aspect they appear intelligent. "Instinct regarded from within becomes intelligence; intelligence regarded from without becomes instinct."

Lloyd Morgan,[14] while admitting that instinctive and intelligent factors are everywhere interwoven in behavior, holds that for psychological analysis they may be distinguished: so far as the form of a response is dependent on heredity it is instinct; so far as it is dependent on previous experience it is intelligent. Instinct includes "all those primary and inherited modes of behavior, including reflex acts, which contribute to what I have termed the primary tissue of experience." While agreeing with Myers that the performance of an instinctive act usually involves some consciousness of meaning derived from previous experience, Morgan points out that this holds only when we have not got to the beginning of experience, which must begin somewhere. For "perfection at the outset" as a criterion of instinct, Morgan would substitute practical serviceability on the occasion of its first performance. All intelligent behavior, he holds, has an instinctive element. "It is that element which cannot be explained by the grouping of the factors of experience, since it is the innate ability so to group them."

H. Wildon Carr [4] presents Bergson's view of instinct. There are, he maintains, abundant examples of instinct without intelligence, as the behavior of ants; and of intelligence without instinct, as the behavior of an admiral directing a naval engagement. There are two main lines of psychic evolution: in vertebrates we have the evolution of intelligence at the sacrifice of instinct, and in invertebrates the evolution of instinct at the expense of intelligence. The fundamental difference between instinct and intelligence is a metaphysical rather than an outwardly observable one. Intelligence is the power of using categories, knowledge of the relations of things. The knowledge which it gives is not direct; to be intelligible is to be explicable in terms of something else. Instinct is inward looking, intuition; it gives direct knowledge, although knowledge limited in scope. Intelligence uses detachable tools: the tools of instinct are organic.

Stout's[19] contribution to the discussion considers three problems that have been raised by the preceding papers. (1) Is it true, as Morgan holds in opposition to Myers, that instinctive behavior cannot at the outset be determined by intelligent consciousness, since intelligence is learning by experience, and at the outset there is no experience? Stout's answer to this question has his characteristic subtlety. An animal performs an action the first time from pure instinct. The second time, its behavior is modified by what it has learned from experience. But when did it do the learning? Surely at the time of the first performance of the action, which then, if learning be the characteristic of intelligence, was intelligent as well as instinctive. Looking at the matter from another point of view, if we say that at the second performance of the action the animal anticipates the sensations and feelings that accompanied its first performance, we cannot explain this anticipation by saying that the sensations and feelings are revived by association, unless there was an element of anticipation in the sensations and feelings at their first occurrence. "If a past process contains no reference to the future, the mere revival of it will not contain any such reference." "I see no intrinsic absurdity in the assumption that even in the commencement of the first performance of an instinctive action, the given situation may be apprehended as about to have a further development."

(2) The Bergsonian position that instinct is a peculiar form of knowing distinct from intelligence, is opposed by Stout. "I find nothing in the instinctive behavior of animals which cannot be accounted for by the combination of certain purely

biological adaptations with psychical processes marked by intelligence fundamentally akin in nature to all other intelligence." Stout would distinguish instinctive action from a series of reflexes by the fact "that in instinct congenital prearrangements of the neuromuscular mechanism for special modes of behavior do not of themselves suffice to explain the animal's conduct. Their biological utility depends from the outset on their operation being sustained, controlled, and guided by intelligent interest in the pursuit of ends."

(3) Is all intelligent activity also instinctively determined? Myers answers this question in the affirmative, Morgan in the negative. [The reviewer does not so understand Morgan.] Here Stout takes issue with Myers, for, he argues, while all intelligent activity depends finally on innate disposition, the inherited predisposition that conditions intelligent behavior is not like that which conditions instinctive behavior. Morgan said that instinctive behavior is marked by being "definite enough to be serviceable;" Stout thinks this too purely biological a criterion, and would substitute for it, as characteristic of instinct, "a definiteness such as would require to be explained as the result of learning by experience or conscious contrivance, if it were not directly provided for by inherited constitution of the nervous system, as determined by the course of biological development." The inherited dispositions which subserve intelligent action, on the other hand, are rather "special readiness to become more or less intensely and persistently interested in activities and objects of a certain kind, and a special retentiveness for the connected experiences."

McDougall[13] would go further than Myers in his assertion that even an instinctive movement must be accompanied by some vague anticipation of results; he does not see why some of the instinctive activities of animals, especially nest-building in birds, should not be guided by actual innate representations. We have here an interesting but hardly convincing revival of the doctrine of innate ideas in its crudest form. McDougall argues, against the Bergsonian theory, that precisely in the solitary wasps, whose behavior is taken by Bergson as representative of pure instinct, we have really a mingling of instinct and intelligence. The principal part of McDougall's paper is devoted to a discussion of the difference between his conception of instinct and that of Stout. McDougall enumerated in his "Social Psychology" a large number of human instincts. Stout would restrict the term so far as human beings are concerned, to a few human movements such as sucking or crawling. The reason for this difference is that Stout means by instincts definite motor mechanisms, while McDougall means inherited dispositions, "conative tendencies," rather than mere movements. The conative tendency is more fundamental than the motor pathways by which it is realized. Further, Stout is to be criticized, according to McDougall, in that his account of instinct neglects the inherited perceptual factors by virtue of which one stimulus attracts attention rather than another.

Myers[16] concludes the discussion by restating his views and reiterating his opinion that "throughout the psychical world there is but one physiological mechanism; there is but one psychological function—instinct-intelligence."

Detailed criticism of the discussion would involve a consideration of the entire psychological systems maintained by the participants. But by way of general comment on the symposium, one may remark that it suffers through being carried on from the point of view of philosophy and of human psychology only, rather than from that of comparative psychology also. With the distinguished exception of Lloyd Morgan, none of the speakers brought to the discussion first-hand acquaintance with the instinctive and intelligent behavior of the lower animals. On the other hand, it is true that comparative psychology is yet too young to pronounce on these matters; nevertheless it is to facts drawn from experiments and observations on animals that such problems must look for solution. The fact is strikingly illustrated by the use made in these papers of the observations of the Peckhams on the solitary wasps; a little actual knowledge puts an end to much argument.

MAST'S "LIGHT AND THE BEHAVIOR OF ORGANISMS" *

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This volume, the major part of which consists of an essay that was awarded the Cartwright Prize by the College of Physicians and Surgeons of Columbia University, is the outgrowth of the author's study of the process of orientation in plants and animals, and deals with the methods by which these organisms regulate their activities so as to bend or move toward or from a source of stimulation. The book is divided into four parts. The first part occupies about sixty pages and consists of an historical account of the researches that have led to the present views concerning the general problem of orientation. The second part, of nearly one hundred and eighty pages, takes up the question of the orientation of organisms and their movements toward or from a source of stimulation. The third part, of some seventy pages, contains a general consideration of the reactions of organisms to light. The fourth and last part, of about sixty pages, is devoted to an account of the effects of colored lights on plants and animals. The volume is concluded with a bibliography of over two hundred titles and an ample index.

The perusal of the book discloses a wealth of facts, many of which are the results of the author's own investigations, and the text consequently has an air of critical authority not often found in extended scientific summaries. The facts, new and old, are marshalled with great consistency and uniformity in support of Jennings's well-known views on animal orientation, and this method of presentation is often so vigorously pursued as to give the reader the impression of special pleading rather than sound judgment. Many of the cases chosen to illustrate the "trial and error" method of orientation must strike the impartial reader as equally good examples for the support of the "tropism" theory. Thus, of the two methods of readjustment to a change in the direction of illumination ascribed to Stentor, the avoidance reaction is an excellent example of the trial and error method, but the gradually curved course that the animal also often takes under these circumstances is an equally good instance of tropic response. Yet throughout the whole account, it is clearly implied that the tropism theory is inapplicable to the movements of Stentor. Nor is it anywhere made clear how an organism, after it has once become oriented, can continue to move in a straight line without involving the essential elements of the tropism theory. To ignore the significance of this part of the reaction as well as of those phases of the operation of orientation that are essentially tropic, gives the text a partisan tone that, to say the least, is regrettable.

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* Mast, S. O. Light and the Behavior of Organisms. New York. John Wiley and Sons, 8vo. XI+410 pp. 1911.

But the chief general defect of the volume is one that has been inherited from earlier students in this field of work, and consists in the attempt to apply the trial and error method of orientation to the movements of many of the higher invertebrates, such as the earthworm, fly larvae, etc., to the exclusion of the tropism idea. Anyone who has watched carefully the orientation of an earthworm or a fly larva in a field of light will have noticed the many fluctuating movements of the head made by these animals during this process. As to the presence of these so-called trial and error movements, there can be not the least question, but as to their significance for orientation there is, in the mind of the reviewer at least, great doubt, for, in any animal that orients more or less directly, these movements are apparently always subordinate to a principle essentially tropic. An example will make this clear. Suppose that, in the case of an earthworm just about to project its head, five preliminary trial and error movements are made. The worm, after having made these movements, is then believed to follow up with an extended locomotor movement that one of the five which was on the whole most favorable for orientation. In this total act the significant part so far as ultimate orientation is concerned is not the making of the five trial and error movements but the final "selection" of the best one as a line to be followed in the real locomotor act. Now it is difficult for the reviewer to see how this "selection" can be accomplished without involving just that feature of symmetrical stimulation which is the essential part of the tropism idea. The worm presumably moves finally in the direction of that trial which through the stimulation of symmetrical points on its body has been found to be most favorable for orientation. Without complicating this problem by raising the question as to the means by which the worm could retain impressions of the five trial and error movements preparatory to following up one of them, it must be evident that these movements in their effect on orientation are quite subordinate to symmetrical stimulation, in fact, not essentially involved in orientation at all. Thus, trial and error movements in the orientation of such animals as the earthworm are wholly secondary occurrences and the orientation of these animals depends in reality upon tropic methods. It is to be regretted that this view of the question should have received no attention in Professor Mast's book, for it is on the basis of criticisms, such as this, that some investigators have regarded the trial and error method when applied to many higher invertebrates as of no real significance.

The minor defects in the volume are slight. Omitted letters occur on page 236, eleventh line from the bottom, and on page 239, eighth line from the top. The bibliography contains no reference to Smith's article on the relations of negative and positive animals in volume thirteen of the *American Journal of Physiology*. It is difficult to understand the ground for the sequence of authors' names such as occurs in the categorical statement made on pages 265 and 266, where, contrary to the common practice, the order of dates is not followed. This looseness at times comes to be really misleading where, for instance on page 52, Verworn precedes Loeb with dates 1886 and 1887, while in the bibliography Loeb's earliest reference is given with the date 1888, and Verworn's with that of 1889. Notwithstanding these minor defects, as well as the general one which was pointed out in the preceding paragraph and which characterizes the work of a class of investigators rather than this volume only, Professor Mast's book is unquestionably the most complete and readable account of the reactions of organisms to light that is accessible to the student of today.

BIBLIOGRAPHY FOR 1910

For the most part, only publications presenting new facts have been reviewed in this number of the Journal.

GENERAL DISCUSSIONS

1. Bohn, G. Introduction de la chimie physique en psychologie. Bull. Inst. gén. psych., x, 205.
2. Bohn, G. L'étude objective des phénomènes cérébraux. Révue des Idées, juin, 1910.
3. Burroughs, J. The Animal Mind. Atlantic Monthly, CVI, 622-631.
4. Carr, H. W. Instinct and Intelligence. Brit. Jour. Psych., III, 230-237.
5. Delage, Y. Comment pensent les bêtes. Bull. Inst. gén. psych., XI, 35.
6. Drzewina, A. Le dressage des animaux. Science au XXe Siécle, Oct., 1910.
7. Franken, A. Möglichkeit und Grundlage einer allgemeinen Psychologie, ins besonderen der Tierpsychologie, Zeit. f. Phil. u. Päd., XVII, 313-325, 361-374, 489-502, 538-549.
8. Hachet-Souplet, P. Psychologie animale. De l'emploi du dressage comme moyen de récherche psychologique. C. r. Acad. Sci., CL, 735.
9. Hachet-Souplet, P. L'association des sensations chez les animaux (la loi de récurrence). C. r. Acad, Sci., CL, 238.
10. Hachet-Souplet, P. Théorie et applications psychologiques du dressage. Bull. Inst. gén. psych., X, 151.

10a. Herrick, C. J. The Evolution of Intelligence and its Organs. Science, XXXI, 7-18.

10b. Holmes, S. J. Pleasure, Pain, and the Beginnings of Intelligence. Jour. Comp. Neur. and Psych., XX, 145-166.

11. Jennings, H. S. Diverse Ideals and Divergent Conclusions in the Study of the Behavior of Lower Organisms. Amer. Jour. Psych., XXI, 349-370.
12. Kostyleff, N. Les travaux de l'école de psychologie russe: étude objective de la pensée. Rev. phil., LXX, 483-507.
13. McDougall, W. Instinct and Intelligence. Brit. Jour. Psych., III, 250-267.
14. Morgan, C. L. Instinct and Intelligence. Brit. Jour. Psych., III, 219-230.
15. Myers, C. S. Instinct and Intelligence. Brit. Jour. Psych., III, 209-219.
16. Myers, C. S. Instinct and Intelligence, a Reply. Brit. Jour. Psych., III, 267-270.
17. Piéron, H. L'évolution de la mémoire. Paris, Flammarion.
18. Sokolowsky, A. Aus dem Seelenleben höherer Tiere. Leipzig, Thomas.
19. Stout, G. F. Instinct and Intelligence. Brit. Jour. Psych., III, 237-250.
20. Thauziés. L'orientation lointaine. Rev. des Idées, mai, 1910.
21. Wasmann, E. La vie psychique des animaux. Rev. de Phil., XVII, 314-321.
22. Wasmann, E. Menschen und Tierseele. 5e Auflage. Köln, Bachen.
23. Watson, J. B. The New Science of Animal Behavior. Harper's Mag., CXX, 346-353.
24. Ziegler, H. E. Der Begriff des Instinktes einst und jetzt. Jena, Fischer.
25. Anon. Neuere Arbeiten zur Tierpsychologie (Zimmer, Franken, Pax) Zeit. f. angew. Psych., IV, 152-186.

LOWER INVERTEBRATES

26. Andrews, E. A. Conjugation in the Crayfish, *Cambarus affinis.* Jour. Exper. Zool., IX, 235-265.
27. Banta, A. M. A Comparison of the Reactions of a Species of Surface Isopod with those of a Cave Species. Jour. Exper. Zool., IX, 243-310, 439-488.

28. Bohn, G. Comparaison entre les réactions des actinies de la Mediterranée et celles des actinies de la Manche. C. r. Soc. Biol., LXVIII, 253.
29. Bohn, G. Les réactions des actinies aux basses températures. C. r. Soc. Biol., LXVIII, 964.
30. Bohn, G. Les réactions des Comatules. Assoc. française pour l'avancement des sciences, Congrés de Toulouse, 5 Août, 1910.
31. Bohn, G. Intervention de la vitesse des réactions chimiques dans la désensibilisation à la lumiere. C. r. Soc. Biol., LXVIII, 1114.
32. Bohn, G. La sensibilisation et la désensibilisation des animaux. Assoc. française pour l'avancement des sciences, Congrès de Toulouse, 5 Août, 1910.
33. Carpenter, F. W. Feeding Reactions of the Rose Coral (Isophyllia). Proc. Amer. Acad. Arts and Sciences, XLVI, 149-162.
34. Cowles, R. P. The Movement of the Starfish, Echinaster, Towards the Light. Zool. Anzeig., XXXV, 193-195.
35. Cowles, R. P. Stimuli Produced by Light and Contact with Solid Walls as Factors in the Behavior of Ophiuroids. Jour. Exper. Zool., IX, 387-417.
36. Dakin, W. J. The Visceral Ganglion of Pecten, with Some Notes on the Physiology of the Nervous System, etc. Mittheil. zool. Station Neapel, XX, 1-40.
37. Drzewina, A. Création d'associations sensorielles chez les Crustacés. C. r. Soc. Biol., LXVIII, 573.
38. Drzewina, A. Contribution à la biologie des Pagures misanthropes. Arch. de zool. expér. et gén., 5e Série, V, 43-55.
39. Doflein, F. Lebensgewöhnheiten und Anpassungen bei Dekapoden Krebsen Festschrift zum sechzigsten Geburtstag Richard Hertwigs, III, 215-292.
40. Ewald, W. E. Ueber Orientirung, Lokomotion, und Lichtreaktionen einiger Cladoceren und deren Bedeutung fur die Theorie der Tropismen. Biol. Cent., XXX, 1-16, 49-63, 379-384, 385-399.
41. Faurot, L. Étude sur les associations entre les Pagures et les Actinies. Arch. de zool. expér. et gén., 5e Série, V, 421-486.
42. Franz, V. Ueber die Bedingungen der Phototaxis bei freibeweglichen Tieren. Zent. f. Physiol., XXIV, 833-837.
43. Hargitt, C. W. Observations on the Spawning Habits of *Hydroides dianthus*. Amer. Nat., XLIV, 376-378.
44. Herbst, C. Ueber die Regeneration von antennenähnliche Organen an Stelle von Augen. VI. Die Bewegungsreaktionen, welche durch Reizung der heteromorphen Antennula ausgelöst werden. Arch. f. Entwicklungsmech., XXX, Heft 2, 1-14.
45. Hess, C. Neue Untersuchungen über den Lichtsinn bei wirbellosen Tieren. Arch. f. d. ges. Physiol., CXXXVI, 282-367.
46. Holmes, S. J. Description of a New Species of Branchipus from Wisconsin, with Observations on its Reactions to Light. Trans. Wis. Acad. Arts and Sciences, XVI, part 2, 1252-1255.
47. Holmes, S. J., and Homuth, E. S. The Seat of Smell in the Crayfish. Biol. Bull., XVIII, 155-160.
48. Hurwitz, S. H. The Reactions of Earthworms to Acids. Proc. Amer. Acad. Arts and Sciences, XLVI, 67-81.
49. Jackson, H. H. T. The Control of Phototactic Reactions in Hyalella by Chemicals. Jour. Comp. Neur. and Psych., XX, 259-263.
50. Kribs, H. G. The Reactions of Aeolosoma (Ehrenberg) to Chemical Stimuli. Jour. Exper. Zool., VIII, 43-75.
51. Loeb, J., and Maxwell, S. S. Further Proof of the Identity of Heliotropism in Animals and Plants. Univ. of Cal. Pub., Physiol., III, 195-197.
52. McClendon, J. F. On Adaptations in Structure and Habits of Some Marine Animals of Tortugas, Florida. Pub. Carnegie Inst., Wash., CXXXII, 57-62.
53. Mast, S. O. Reactions of Amoeba to Light. Jour. Exper. Zool., IX, 265-279.

54. Matisse, G. Action de la chaleur et du froid sur l'activité motrice et la sensibilité de quelques invertebrés marins. Bull. Station biol. d' Arcachon, XIII, 1-52.

55. Moore, A. R. On the Righting Movements of the Starfish. Biol. Bull., XIX, 235-239.

55a. Morgulis, S. The Movements of the Earthworm: a Study of a Neglected Factor. Jour. Comp. Neur. and Psych., XX, 615-624.

56. Morse, M. Alleged Rhythm in Phototaxis Synchronous with Ocean Tides. Proc. Soc. Exper. Zool. and Medicine, VII, 145-146.

57. Parker, G. H. The Reactions of Sponges, with a Consideration of the Origin of the Nervous System. Jour. Exper. Zool., VIII, 1-43.

58. Polimanti, O. Les céphalopodes ont-ils une mémoire? Arch. de Psych., X, 84-87.

59. Prowazek, S. von. Einführung in die Physiologie der einzelligen Protozoen. Leipzig and Berlin, pp. 172.

60. Rose. M. Sur quelques tropismes. C. r. Acad. Sci., CL, 1543-2545.

61. Schaeffer, A. A. Selection of Food in *Stentor coeruleus* (Ehr.). Jour. Exper. Zool., VIII, 75-132.

62. Simroth, H. Quelques rémarques sur la locomotion des gastéropodes. Bull. Soc. Zool. France, XXXV, 10-14.

SPIDERS AND INSECTS OTHER THAN ANTS

63. Barnes, W. Notes on the Life History of *Anisota Skinneri* Bied. Canadian Entom., XLII, 400-403.

64. Bueno, J. R. De La Torre. Life Histories of American Water-Bugs, III. Canadian Entom., XLII, 176-186.

65. Criddle, N. Habits of Some Manitoba Tiger Beetles, II. Canadian Entom., XLII, 9-15.

66. Ferton, C. Notes detachées sur l'instinct des Hymenoptères melliféres et ravisseurs. Ann. Soc. Entom., LXXIX, 145-178.

67. Forel, A. Das Sinnesleben der Inseckten. Muenchen, Reinhardt, pp. xv + 393.

68. Graenicher, S. The Bee-Flies in Their Relations to Flowers. Wis. Nat. Hist. Soc., VIII, 91-101.

69. Knorez, K. Die Insekten in Sage, Sitte und Literatur. Annaberg (Sachsen), Grafers Verlag (Richard Liesche), pp. 151.

70. Lovell, John H. The Color Sense of the Honey Bee; Can Bees Distinguish Colors? Am. Nat., XLIV, 673-692.

71. McDermott, F. Alex. A Note on Light-Emission of Some American Lampyridae. Canadian Entom., XLII, 357-363.

72. McIndoo, N. E. Biology of the Shawnee Cave Spiders. Biol. Bull., XIX, 303-323.

73. Mast, S. O. Do Blow Fly Larvae Respond to Gravity? Biol. Bull., XVIII, 191-192.

74. Mitzmain, M. B. Some New Facts on the Bionomics of the California Rodent Fleas. Ann. Ent. Soc. Am., III, 61-82.

75. Montgomery, T. H., Jr. The Significance of Courtship and Secondary Sexual Characters of Araneads. Am. Nat., XLIV, 151-177.

76. Morgan, T. H., and Shull, A. F. The Life Cycle of *Homaphis hamamelidis*. Ann. Ent. Soc. Am., III, 144-146.

77. Petrunkevitch, A. Courtship of *Dysdera crocata*. Biol. Bull., XIX, 127-129.

78. Rau, Philip. Observations on the Duration of Life, on Copulation and on Oviposition in *Samia Cecropia*, Linn. Trans. Acad. of Sci. of St. Louis, XIX, 21-48.

79. Roubaud, E. Sur la biologie des Synagris. Ann. Soc. Entom., LXXIX, 1-20.

80. Roubaud, E. L'evolution de l'instinct chez les Vespides. C. r. Acad. Sci., CLI, 553.

81. Sanders, G. E. Habits of *Disognus pubescens*. Canadian Entom., XLII, 42, 48.
82. Turner, C. H. Experiments on Color Vision of the Honey Bee. Biol. Bull., XIX, 257-279.
83. Webster, F. M. A Predaceous and Supposedly Beneficial Mite, *Pediculoides*, Becomes Noxious to Man. Ann. Entom. Soc. Am., III, 15-39; Pl. III-V.

ANTS, THEIR GUESTS AND PARASITES

84. Brun, Rudolph. Zur Biologie und Physiologie von *Formica rufa* und anderen Ameisen. Biol. Cent., XXX, 524-545.
85. Burrill, A. C. How Sanguinary Ants Change at Will the Direction of Column in Their Forays (*F. sanguinea* var.). Bull. Wis. Nat. Hist. Soc., VIII, No. 3, 123-131, 2 figs.
86. Cornetz, Victor. Trajets de Fourmis et retours au nid. Mém. Inst. gén. Psych. No. 2, 1910, 167 pp.; album et texte explic.
87. Cornetz, Victor. Une règle de constance dans les trajets lointains de la Fourmi exploratrice. Rev. des Idées, Dec. 5, 1910, 16 pp.
88. Crawley, C. How Ants Greet Members of the Same Colony. Ent. Rec. & Journ. Var., XXII, 43-44.
89. Crawley, C. Workers of *Lasius flavus* (? *L. umbratus*) among *L. fuliginosus*. *Ibid.*, 67-69
90. Crawley, C. Ants and *Platyarthrus hoffmanseggi*. *Ibid.*, 129-130.
91. Crawley, C. Summary of Experiments with Fertile Females of Several Species of Ants. *Ibid.*, 152-156.
92. Crawley, C. Experiments with Ants' Nests. *Ibid.*, 304.
93. Donisthorpe, H. S. J. K. On the Founding of Nests by Ants; and a few Notes on Myrmecophiles. *Ibid.*, XXII, 82-85.
94. Donisthorpe, H. S. J. K. Hearing in Ants. *Ibid.*, XXII, 117.
95. Donisthorpe, H. S. J. K. Myrmecophilous Notes for 1910. *Ibid.*, XXI-XXII, Nos. 10, 11 & 1, 291, 15-17.
96. Donisthorpe, H. S. J. K. Some Experiments with Ants' Nests. Trans. Ent. Soc. London, XXII, 142-150.
97. Emery, Carlo. Considerazioni intorno alla regola del Dzierzon sulla determinazione del sesso nelle Api e in altri Imenotteri. R. Accad. Sci. Ist. Bologna, 1910, 29-39.
98. Emery, Carlo. Il Polimorfismo e la Fondazione della Societa negli Insetti Sociali. "Scienzia" Riv. d Scienza, VII, anno IV, No. XIV-2, 336-349.
99. Jacobson, Edward. *Pheidologeton diversus* Jerdon und eine myrmecophile Fliegenart. Tÿdschr. v. Ent. Deel., LIII, 1910, 328-335.
100. Kneissl, Ludwig. Zur Kenntnis des myrmekophilen *Uropolyaspis hamuliferus* (Mich.). Berl. und zur Biologie der Ameisenmilben. Zeitschr. f. wiss. Insektbiol., VI, 228-231.
101. Krüger, Erich. Beiträge zur Anatomie und Biologie des *Claviger testaceus* Preyssl. Zeitschr. f. wiss. Zool., XCV, Heft. 2, 327-381, Pl. XI, XIa, 33 text figs.
102. Lea, A. M. Australian and Tasmanian Coleoptera Inhabiting or Resorting to the Nests of Ants, Bees, and Termites. Proc. Roy. Soc. Victoria, XXIII, 116-230, 3 pls.
103. Marsh, H. O. Notes on a Colorado Ant (*Formica cinereorufibarbis* Forel). U. S. Dept. Agric. Bur. Ent., Bull. No. 64, Pt. IX, 73-78.
104. de Meijere, J. C. H. Ueber drei von Jacobson auf Java bei *Pheidologeton diversus* Jerdon beobachtete Fliegen. Tijdschr. v. Ent. Deel., LIII, 336-340.
105. Neger, F. W. Neue Beobachtungen an körnersammelnden Ameisen. Biol. Cent., XXX, 138-150, 3 figs.
106. O'Brien, R. A. Remarks on the Habits of the Green Tree-Ant of Australia (note). Proc. Zool. Soc. London, 1910, 669-670.

107. Pierce, W. D. Note on the nest-building habits of *Pogonomyrmex barbatus molefaciens* Buckley. Proc. Ent. Soc. Wash., XII, 97, 98.

108. Piéron, Henri. La génèse des instincts esclavagistes et parasitaires chez les Fourmis. Rev. gén. Sci. pures et appliquées, 21° Année, 726-736, 767-779.

109. Santschi, F. Notes sur la Polyandrie chez les Fourmis. Bull. Soc. d'Hist. Nat. del Afr. du Nord, II, 3 pp.

110. Schimmer, F. Ueber die Wasmannsche Hypothese des "Duldungsinstinktes" der Ameisen gegenüber synöker Myrmekophilen. Zool. Anzeig., XXXVI, 81-95.

111. Schmitz, H. (S. J.) Die Ursachen der Doppelwirtigkeit bei Atemeles. Deutsch. Ent. Nat. Bibliothek, I, 6-7, 13-14.

112. Vickery, R. A. Contributions to a Knowledge of the Corn Root-Aphis. Bull. No. 85, Pt. VI, U. S. Dept. Agric., 97-118, 7 figs.

113. Viehmeyer, H. On the Myrmecophily of Caterpillars of *Catochrysops cnejus* Fabr. Philippine Journ. Sci., V, No. 1, Sect. D, June, 1910, 69-72.

114. Viehmeyer, H. A Myrmecophilous Lycaenid Chrysalis from the Philippines. *Ibid.*, 73-77, 4 figs.

115. Viehmeyer, H. Ontogenetische und phylogenetische Betrachtungen über die abhängige Koloniegründung von *Formica sanguinea.* Biol. Cent., XXX, 569-580.

116. Viehmeyer, H. Bemerkungen zu Wasmann's neuester Arbeit: Ueber den Ursprung des sozialen Parasitismus, der Sklaverei und der Myrmecophilie bei den Ameisen. Zool. Anzeig., XXXV, 450-457.

117. Wasmann, E. (S. J.) Staphylinius-Arten als Ameisenräuber. Zeit. f. Insektenbiol, VI, Heft 1, 5-10, 37-39.

118. Wasmann, E. (S. J.) Ueber das Wesen und den Ursprung der Symphilie. Biol. Cent., XXX, 97-102, 129-138, 161-181, 1 fig.

119. Wasmann, E. (S. J.) Nils Holmgren's neue Termitenstudien und seine Exsudattheorie. Biol. Cent., XXX, 303-310.

120. Wasmann, E. (S. J.) Zur Doppelwirtigkeit der Atemeles. Deutsch. Ent Nat. Biblio. I, Nos. 7 & 8, 55, 56; 62-64.

121. Wasmann, E. (S. J.) Nachträge zum sozialen Parasitismus und der Sklaverei bei den Ameisen. Biol. Cent., XXX, 453-464, 475-496, 515-524.

122. Wellman, C. Unusual Parasitic Habits of an African Ephydrid. (Transl. from Zeit. f. wiss. Insektenbiol. Nov. 18, 1909, p. 356). Psyche, XVII, 8.

123. Wheeler, W. M. Ants, their Structure, Development and Behavior. Columbia Univ. Press, N. Y., pp. xxv-663, 286 text figs.

124. Woodworth, C. W. The Control of the Argentine Ant. Univ. Calif. Publ. Bull. No. 207, Berkeley, Calif., 53-82, 28 figs.

VERTEBRATES

125. Bauer, V. Ueber das Farbenunterscheidungsvermögen der Fische. Arch. f. d. ges. Physiol., CXXXIII, 7-27.

126. Bernoulli, A. L. Zur Frage des Hörvermögens der Fische. Arch. f. d. ges. Physiol., CXXXIV, 633-644.

127. Cole, L. W. Reactions of Frogs to Chlorides of Ammonium, Potassium, Sodium, and Lithium. Jour. Comp. Neu. and Psych., XX, 601, 614.

128. Franken, A. Instinkt und Intelligenz eines Hundes. Zeit. f. angewand. Psych., IV, 1-64; V, 399-464.

129. Franz, V. Phototaxis und Wanderung: nach Versuchen mit Jungfischen und Fischlarven. Int. Rev. der ges. Hydrobiologie und Hydrographie, III, 306-334.

130. Glaser, O. C. The Formation of Habits at High Speed. Jour. Comp. Neur. and Psych., XX, 165-184.

131. Greene, C. W. An Experimental Determination of the Speed of Migration of Salmon in the Columbia River. Jour. Exper. Zool., IX, 579-592.

132. Hachet-Souplet. Quelques expériences nouvelles sur les pigeons voyageurs. VI Congrès International de Psychologie., 663-673.

133. Herrick, F. H. The Life and Behavior of the Cuckoo. Jour. Exper. Zool., IX, 169-234.

134. Herrick, F. H. Instinct and Intelligence in Birds. Pop. Sci. Mo., LXXVI, 532-556; LXXVII, 82-97, 122-141.

135. Hess, C. Ueber den angeblichen Nachweis von Farbensinn bei Fischen. Arch. f. d. ges. Physiol., CXXXIV, 1-15.

136. Hess, C. Untersuchungen über den Lichtsinn bei Reptilien und Amphibien. Arch. f. d. ges. Physiol., CXXXII, 255-295.

137. Parker, G. H. Olfactory Reactions in Fishes. Jour. Exper. Zool., VIII, 535-541.

138. Pearse, A. S. The Reactions of Amphibians to Light. Proc. Amer. Acad. Arts and Sciences, XLV, 161.

139. Porter, J. P. Intelligence and Imitation in Birds; a Criterion of Imitation. Amer. Jour. Psych., XXI, 1-71.

140. Sokolowsky, A. Genossenschaftsleben der Säugetiere. Leipzig, Weigel.

141. Shepherd, W. T. Some Mental Processes of the Rhesus Monkey. Psychol. Mon., XII, 5.

142. Swift, W. B. Demonstration eines Hundes dem beide Schläfenlappen exstirpiert worden sind. Neur. Cent., XXIX, 686-688.

143. Thauziés, A. Expérience d'orientation lointaine. Arch. de Psych., IV, 66.

144. Thauziés, A. L'orientation lointaine. VI Congrès International de Psychologie, 263-276.

145. Watson, J. B. Further Data on the Homing Sense of Noddy and Sooty Terns. Science, XXXII, 470-473.

146. Waugh, K. T. The Rôle of Vision in the Mental Life of the Mouse. Jour. Comp. Neur. and Psych., XX, 549-599.

147. Witmer, L. Intelligent Imitation and Curiosity in a Monkey. Psych. Clinic. III, 225-227.

148. Witmer, L. A Monkey with a Mind. *Ibid.*, III, 179-205.

149. Yerkes, R. M., and Bloomfield, D. Do Kittens Instinctively Kill Mice? Psych. Bull., VII, 253-263.

150. Zeliony, G. S. Ueber die Reaktion der Katze auf Tonreize. Zent. f. Physiol., XXIII, 762-767